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A VISIT TO THE HANGCHOW BORE

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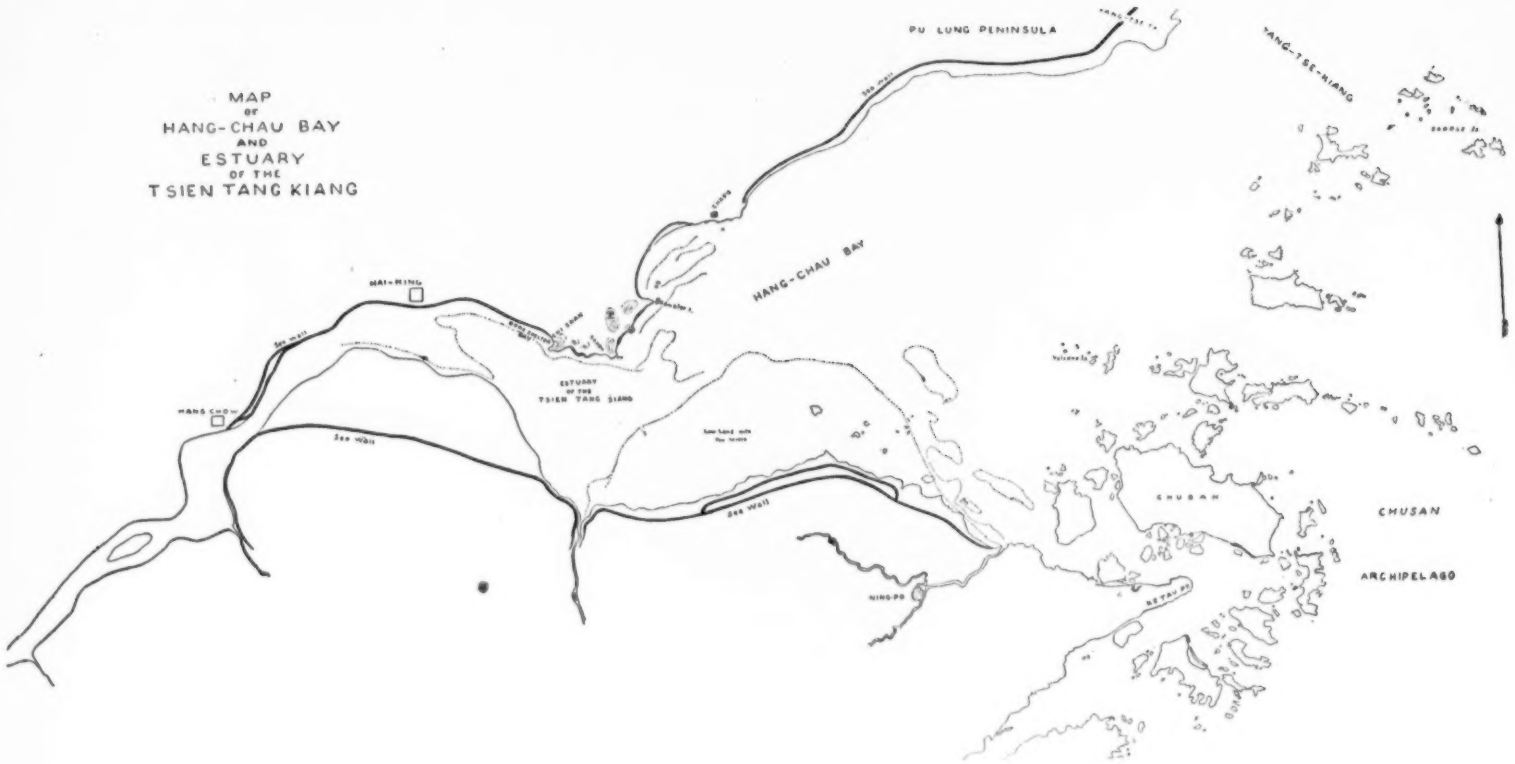
I

Introductory

THE most striking thing, from a geographical point of view, which is to be seen along the China coast is the recurrent phenomenon which we are about to describe. The rugged coast line, the many bays, the chain of islands fringing the coast, the whole gamut of geological and geographical forms which one encounters in an intimate coastwise journey, are all very striking and grand, and yet they are static—passive, after all. Notable as they are, they are but silent witnesses of those restless and resistless forces which have brought them into being. But when one beholds the mighty Yangtse and attempts to form an estimate of the volume of silt carried seaward in the rush of its muddy waters, and tries to judge of its land-forming as well as its land-denuding powers, one stands in the presence of dynamic grandeur, which to our mind exceeds the passive greatness as of the "everlasting" yet silent hills. It is this appreciation of dynamic greatness which overwhelms an observer of the tidal bore as it sweeps in from Hangchow Bay and rushes past Haining, a solid wall of water from two and a half to three miles wide, perhaps ten, twelve or even twenty feet high, with a speed of ten to twenty miles an hour, according to the intensity of the tide. Imagine, if you can, one and three quarter millions of tons of water passing by you each minute, the rush to continue several tens of minutes, and you will have no difficulty in believing that this inrush of water makes itself felt still as a big wave at Hangchow, thirty miles farther inland, and even for some miles beyond.


MAP
OF
HANG-CHAU BAY
AND
ESTUARY
OF THE
TSIEN TANG KIANG
PU LUNG PENINSULA
YANG-TSE-KIANG
HANG-CHAU BAY
HAI-NING
HANG CHOW
ESTUARY
OF THE
TSIEN TANG KIANG
Sea Wall
CHUSAN
CHUSAN
ARCHIPELAGO
NING-PO

Unlike the bores seen elsewhere, which generally occur intermittently, the Hangchow bore ascends the river at every tide, though its magnitude and speed vary considerably with the general state of the tides, and semi-monthly maxima are attained at the third tide after each new and each full moon. The latter affords a better opportunity to witness the bore under the more impressive and majestic stillness of midnight and the light and shadow of a moonlit scene. These semi-monthly maxima themselves attain greatest intensity at the times of greatest tides. Of these the autumnal equinox is preferable because of the cool and most probably fair weather and the absence of mosquitoes. The eighteenth of the Chinese eighth month is gen-

THE BUND AT SHANGHAI. CLOCK TOWER OF CUSTOMS HOUSE SHOWS IN THE DISTANCE.

erally reckoned as the time of the greatest bore of the year. In the fall of 1906 the writer spent the first and second days after the seventh full moon (September 6 and 7) in close observation of one midnight and two noon bores.

Although observers sometimes go to Kanpu beyond the mouth of the Ch'ien-tang Kiang, and others content themselves with a view from Hangchow, from the first of these places the bore is seen when not fully formed, its two initial sections not yet united, while at Hangchow the effect, though still fairly remarkable, has completely lost its grandeur; and the best and most easily reached vantage ground is at the Haining Pagoda, though it is likely that at a point some five miles below the pagoda the bore is of even greater grandeur. This is close to where the two branches of the furious "Serpent's Head," as the

FOOT-BOAT, A FAST PASSENGER CRAFT ON CANALS IN YANGTSE DELTA. THE SIDE OAR IS BEING OPERATED BY THE FEET.

Chinese call it, meet, and some observers have reported thirty feet for its height there as against nine feet reported at the pagoda for the same bore, though we suspect that they refer to the height of the temporary waves caused by the impact of the two branches, and not to the height of the bore-front proper.

THE JOURNEY TO HAINING

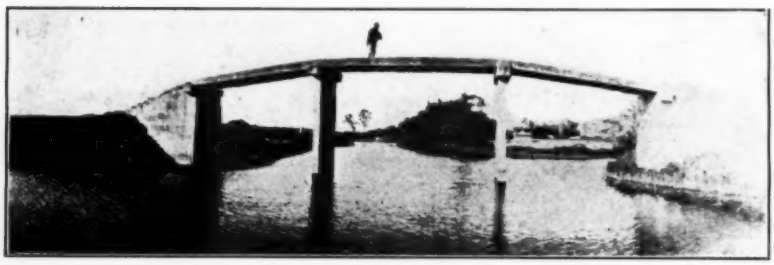
Haining lies within and near the northwestern side of the equilateral triangle formed by Hangchow, Ningpo and Shanghai, and is readily reached from the last named by means of a so-called canal "train," a steam-launch towing three to six boats of various kinds. One may hire a horse-boat, Chinese or foreign style, or, as we did, take a cabin on one of the native passenger barges operated by the launch companies. Small cabins for two cost five dollars, Mexican, from Shanghai to Hangchow, and a very large one, enough for a party of six or eight, may be rented for twelve dollars, Mexican, for the one way. House-boats cost upwards of five dollars, Mexican, a day, according to size and fittings, and towing is extra.

Two or three of these launch-trains leave Shanghai from their landings in Soochow Creek every afternoon about five o'clock and

with fair weather and favorable tides reach Hangchow the next afternoon anywhere after three o'clock. Three companies are now running these trains, two Chinese and one Japanese. Everything is managed in a creditable and business-like fashion, and one can make a fairly comfortable trip at reasonable expense. It is possible, using this launch service, to leave Shanghai on Friday night, see the Saturday night and Sunday afternoon bores, and be back in Shanghai on Monday morning. By private launch even better time can be made and a record round-trip of sixty hours, allowing fifteen hours at Haining to witness both a day and a night bore, and five hours of shooting during the return, was made by some Shanghai enthusiasts in October, 1902. On the other hand, the pleasures of house-boating in the region traversed, especially during the fall months, should not be underestimated, and if one is not pressed for time a very comfortable and interesting trip on a private boat, propelled by *yulow* and pole and landing you at the Haining Pagoda at the end of the third day from Shanghai, will allow a full enjoyment of the various scenes which enliven the river and canal banks throughout the Yangtse's delta. A satisfactory compromise between these two plans may be effected by taking a cabin passage on a launch train as far as Samen on the Grand Canal, which is reached at noon of the day after leaving Shanghai, and then hiring a native boat to be *yulowed* along narrow, well-shaded canals to Haining, which under fair conditions should be reached by six or seven o'clock that evening.

Leaving the wharf in Soochow Creek, Shanghai, shortly before

AN ORDINARY PASSENGER CRAFT USED BY THE AUTHOR FOR THE TRIP.
SAMEN — HAINUNG — HANGCHOW.



LONG GRANITE SLABS FORMING A SIMPLE BRIDGE.

sunset, we passed under the Garden Bridge, from which many pairs of curious eyes watched our departure, the sturdy little tug puffing continuously and tooting spasmodically as it entered the Whangpu River to pass along the length of the Bund and native city wharves, thus affording an unexcelled view of Shanghai's glory. After rounding a bend toward the southeast our course was southward up the river to Sankong, from there west as far as the walled city of Sungkiang, and further, winding around in a west by south direction, we passed out of Kiangsu province into Chehkiang and came to Kashing, a walled city with a customs station under the management of the Hangchow customs. Here we entered the Grand Canal and followed its southwesterly course through several unimportant but crowded places, at one of which Samen, or Shih Men, we left the launch-train and proceeded in a native boat southeasterly toward Haining by means of the by-way canals which traverse the delta as frequently as cross-roads are found in the country districts of western lands. At Samen, the Grand Canal proper makes a right-angled turn to the west as far as Dongsi, or Tang Hsi, where another right-angled turn gives it a straight course southward to Hangchow, its terminus.

All along we found the canals full of life, large boats laden with firewood passing down to Shanghai, while smaller boats with market supplies and other articles were met plying between intermediate points. Large rafts of fir or bamboo, sometimes stretching as far as one could see, excited wonder as to how four or at most five men

AT A BEND IN THE GRAND CANAL.

succeeded in managing them so well. Curious foot-boats here take the place of the slipper boat so common in the Canton Delta as a rapid passenger craft. They are long narrow affairs and owe their name to the peculiar fashion in which they are propelled. A single boatman sits in the stern and *yulows,* or wiggle-waggles a large tail oar, and at the same time operates a long oar slung over the starboard side, by means of both feet placed on the inner end—one on the round handle of the oar, and the other on the flat side of a good-sized wooden block attached to the oar-end at right-angles. These boats carry passengers, mails and parcels between the intermediate places not served by the launch-trains or on the side canals.

On both sides of the canal, especially near Kashing, fine granite memorial arches and several pagodas stand conspicuous, having escaped or baffled the destroying hand of the Taipings, though most other things in this region suffered woefully. At one turning point we noticed three graceful pagodas standing side by side.

But the most frequent and most notable feature encountered during a trip on these canals is the really wonderful series of bridges under which the traveler passes. Wooden bridges, granite bridges, crude bridges, artistic and picturesque bridges, dilapidated bridges and bridges in good repair. Bridges with sloping approaches and high curving arches, bridges with one arch or with several, all devoid of prominent keystones. Bridges crowned with shops or pavilions. Bridges whose sides are covered with verdant vines and with small trees clumped at either end. Bridges from the tops of which expectant fishermen let down the great umbrella net and blame the passing boat for the non-appearance of a decent "catch." Bridges which sometimes by their massive piers and narrow arches so reduce the waterway and increase the stream's flow that the spice of danger is added for the voyager whose craft may be a little over normal size. Later, while returning from a side trip to Mokanshan on a dark and rainy night, the cabin loft for servants at the rear of the house-boat we were using was almost completely demolished by crashing into the corner of one of the side arches of the bridge at Dongsi.

On some of the straight stretches of the canal as many as three bridges were sometimes seen from a single position, for every village must have its bridge, and settlements are so frequent that a canal is a veritable "stringtown on the pike." When the canals pass through towns and villages, the natives seem to exercise their best ingenuity in obstructing the already narrow space to the utmost passable limits, by building overhanging porticos and pavilions or by mooring their craft on either side without regard to the resulting constriction. In many cases these bridge arches have more than a half-circle of opening and are fine examples of the stonemason's art and skill. With regular and

A Pair of Crude but Useful Structures

solid granite approaches on either side, having sometimes a simple open rest house, washed red on the outside, or a small group of houses at one end, about which cluster a few large trees, they often present charming pictures, especially when a bright day allows every outline to be reflected from the water and the observer is sufficiently distant to miss the inevitable dirt of a Chinese rural dwelling place.

So-called river "gunboats," usually tied up in a shady spot near

a village and large mandarin family boats were frequently met with. The most curious of all the craft encountered, however, were the cormorant fishermen's boats or rafts, with the berumpled and rather miserable-looking black birds crouching upon them or swimming alongside. Usually the fisherman was stamping rhythmically upon a loose board in the stern and *yulowing* his boat at a fair pace, some of the birds swimming alongside with a bobbing kind of motion in unison with this stamping, and every now and then making a dive for fish which were no doubt expected to be attracted by the boatman's noise, though to judge from our observation the returns for all this scheming were very meager.

Occasionally a grating sound under the bottom of the boat told us that we were passing over the loose central portion of the reed and bamboo fish-traps or wires which frequently extended completely across the stream, but always with an apparently unoccupied reception or storage compartment at one corner. At other times the progress of our light craft was somewhat impeded by the heavy growths of water weeds and cresses.

The banks of the canal are everywhere green and restful, and in the case of the smaller by-ways are often completely overhung. We have seen nothing finer of the same sort anywhere, the famous Fenways of Boston not excepted. Bushes, great grasses, trees straight and tall, dwarfish and crooked trees, laurel, graceful weeping willow, flowering shrubs, and non-flowering covered with some blooming vine—the whole a beautiful fenway for mile after mile.

The predominant feature is the mulberry-tree, showing everywhere the importance of this region as a silk producer. In well-kept rows, their crooked and wide-spreading branches hid beneath rounded canopies of huge pale-green leaves, the ground everywhere clear of other growth, these little trees represent no small part of the material wealth of a region famous for the splendid silken garments produced in its chief cities.

These mulberry groves sometimes alternate with clumps of graceful bamboos or spicy odorous pines, which mark the burial ground of the near-by village. Or again there is only a fringe of mulberry trees along the bank, much as the lichee trees occur in the delta near Canton, with the paddy fields soon to become bean fields after the rice harvest, or the lotus ponds all white and pink in their September glory, lying behind this fringe or veil.

Haining was reached at eight P.M. in the midst of a pouring rain. Passing around the wall on two sides, our journey came to an end in the *cul de sac* with which the canal abruptly terminates, near a somewhat picturesque gateway in the city wall. A five minutes' walk from our mooring at the canal's end brought us to the sea wall and

A Pair of Ornamental as well as Useful Structures.

the pagoda, and after witnessing the bore which swept past us at about 1:15 A.M. we again crawled into our not overlarge boat and enjoyed a half-night's dozing on hard boards.

Some Considerations concerning Tides in General

Bores Elsewhere

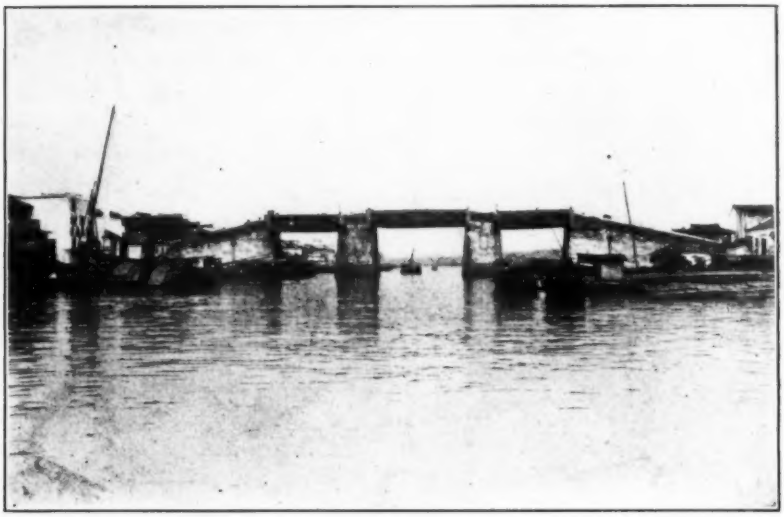
Before describing the Hangchow Bore as we saw it at Haining, some preliminary remarks about tides in general, and especially about tidal

currents in rivers, will enable the general reader to understand better the phenomenon we are about to consider, and to appreciate its proper place as compared with other more general and ordinary tidal phenomena. This must be our justification for presenting here much that can be found elsewhere and is already matter of common knowledge, but which needs to be correlated and reviewed in this present connection.

The discrepancies in the range of the tides at different places are due chiefly to the local conformations of coasts and sea-beds. Indeed, it seems, as Sir Robert Ball has pointed out, that if the whole earth were covered with a uniform and deep ocean of water, the tides would be excessively feeble, since barometric records give no very distinct evidence of tides in the atmosphere, which is a deep and vast ocean of air embracing the whole earth to a practically uniform depth.

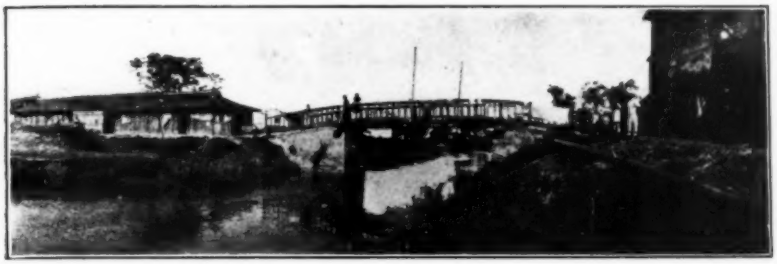
Along the borders of land areas the range of the tide is found to vary from zero up to seventy feet. Few of us realize how small the range is in some places, where at first sight we should expect it to be considerable. In midocean, for instance, an island like St. Helena is washed by a tide only about three feet in range; an enclosed sea like the Caspian or the Black is subject to no appreciable tides whatever, and even the Mediterranean, notwithstanding its connection with the great Atlantic, is subject in general to inconsiderable tides, the range of water-level varying from eight inches at Brindisi to two feet four inches at Trieste. The Mediterranean tides are, however, more strongly developed in the Bay of Gibraltar (where the range is from five feet to six feet five inches), the upper Adriatic and the Gulf of Gabes.

In the deep wide reaches of the ocean, the tidal elevation progresses at the tremendous rate of about five hundred geographical miles an hour. But as this is merely the passing of an oscillation whereby the particles of water are gently moved through a cycle of positions, there can be no appreciable effect upon the distant ocean bottom, on an average of two or three thousand fathoms below. When, however, the tidal wave enters a shallow sea, the friction of the bottom becomes more and more effective in decreasing the speed while it increases the height and effective force of the wave. Again, when the tidal swelling is increased in height by the convergence of the shores between which it moves, it is no longer a mere oscillation or pulsation of the great ocean, but the water acquires a true motion of translation, and rushes past headlands and through narrow channels with tremendous force and speed—a phenomenon well known along the west coasts of Scotland and Scandinavia. In some cases the advancing tide on entering a narrow inlet or estuary gathers itself into one or more large waves, and rushes up between the converging shores. Thus, owing to the gradual



A CONTRAST IN CONSTRUCTION.

decrease in width and depth of the Bristol Channel the tide enters the Severn with great force, forming a tidal wave or bore which at times attains a height of nine feet and has on several occasions caused great destruction, as in 1606, 1687, 1703 and 1883. The Bristol Channel also concentrates the great wave which gives Chepstow and Cardiff a tidal range which sometimes reaches fifty feet. In like manner, the tides which enter the Bay of Fundy between Novia Scotia and New Brunswick are more and more cooped up and rise higher as they ascend the strait, till they reach a height of seventy feet. But these changes are gradual, not really sudden enough to constitute a properly



A CRUDE BRIDGE.

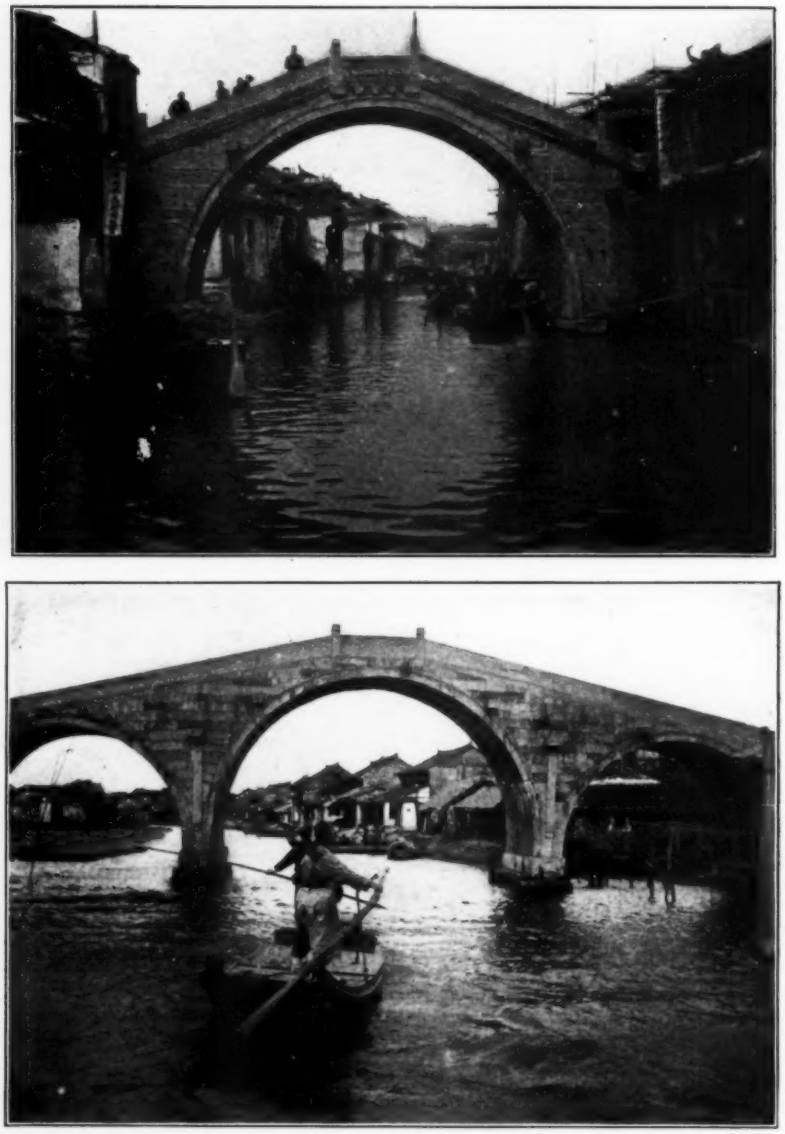
called "bore." Professor G. H. Darwin noted on the banks of the Severn during the spring tide in September, 1897, that there was no proper bore, but only a succession of waves up-stream, and a rapid rise of water-level.

In the case of the River Seine, which has been dyked as far as Rouen to admit vessels of twenty feet draught, it is said that there is a bore (*barre* or *mascaret*) at every tide, ranging usually from eight to ten feet. This is probably accounted for by the fact that after Candebec and Quillebœuf, the estuary is set with extensive sand-banks between which flows a narrow navigable channel.

These bores are relatively small compared with that in the Ch'ien-tang Kiang, while the destructive bore of the great Amazon is robbed of its impressiveness because it can not be well observed on account of its very magnitude; moreover, with it as well as with the other rivers it is only at spring tides and with certain winds that the phenomenon is at all striking. On the other hand, the Hangchow Bore occurs at every tide to a remarkable extent in any season and at certain times assumes colossal proportions and is always easily observable. For comparison it may be interesting to note the following description of the Amazon's bore, or *proroca,* by La Condamine:

During three days before the new and full moons, the period of the highest tides, the sea, instead of occupying six hours to reach its flood, swells to its highest limit in one or two minutes. The noise of this terrible flood is heard five or six miles off, and increases as it approaches. Presently you see a liquid promontory twelve or fifteen feet high, followed by another, and another, and

AN ARTISTIC BRIDGE—A COMMON TYPE.



TYPICAL BRIDGE OF SUBSTANTIAL CHARACTER. NOTE THE ABSENCE OF PROMINENT KEYSTONES.

sometimes by a fourth. These watery mountains spread across the whole channel, and advance with a prodigious rapidity, rending and crushing everything in their way. Immense trees are sometimes uprooted by it and sometimes whole tracts of land are swept away.

Tidal Currents in Rivers[1]

There is no appreciable tidal effect in rivers due directly to the tidal attraction of the sun and moon, but the tidal wave in a river is

[1] See G. H. Darwin, "The Tides," etc., Scribners, 1898. This contains also an account of the Hangchow Bore based on Captain Moore's survey, to which we shall refer later on.

caused by the oscillation of the larger body of water into which the river empties. The sea resembles a large pond in which the water rises and falls with the oceanic tide, and a river is a canal leading into it. The rhythmical rise and fall of the sea generates waves which would travel up the river, whatever were the cause of the oscillation of the sea and quite independent of any direct action of the sun and moon on the water of the river itself.

There are four characteristics of tidal currents in rivers which are of cardinal importance in the present connection. Briefly treated, they are:

1. *Dependence of Speed on the Depth Alone.*—It may readily be shown mathematically that long waves travel in shallow water at a speed which depends only on the depth of the water, and that waves are to be considered long when their length is at least twice the depth of the water. Now the tidal wave in a river is many hundreds of times as long as the depth, and consequently it travels at a speed dependent only on the depth of the river. Moreover, its speed is very slow compared with the motion of the great tide wave in the open sea.

2. *Difference between Ebb and Flow in a River and along an Open Coast.*—On the open seacoast ebb and flow are simultaneous with fall and rise, but in a river the case is quite different. On an open coast slack water occurs at high and low water, but in a uniform canal connecting with the sea, slack water, *i. e.*, the time of no tidal current, is at mean water-level, the current being most rapid up-stream at the water-level, it ceases flowing before mean water-level is reached; and

A CONSTRICTED ARCHING. NOTE THE LACK OF PROMINENT KEYSTONE.

GUARDING THE GRAND CANAL

moment of high water and most rapid down-stream at low water. Hence the tidal current "flows" for a long time after high water has passed and when the water-level is falling, and "ebbs" for a long time after low water and when the water-level is rising. But rivers gradually broaden and become deeper as they approach the coast, and tidal currents in actual estuaries are, therefore, intermediate between those of an open seacoast and those in a uniform canal.

A STRING-TOWN ON A CHINESE "PIKE."

3. *Effect of Proper Current of the River Itself.*—A river has also to deliver a large amount of water into the sea during a single oscillation of the tide, and its own proper current is superposed on the tidal currents. Hence in actual rivers, while the resultant current continues to flow up-stream after high water is reached, with falling water-level, it ceases flowing before mean water-level is reached; and while the resultant current ebbs down-stream after low water, it generally continues to ebb with the rising tide for some time after mean water is reached, the downward stream, in fact, lasting longer than the upward one. The moments at which currents change will differ in each river according to the depth, the time and the extent of the rise and fall at the mouth and the volume of water delivered by the river; but in every case the tide rises more quickly than it falls, so that the time-interval from low water to high water is shorter than from high to low.

4. *Natural Change in Shape of a Wave Advancing into Shallow Water.*—The demonstration is too technical to be included here, but it can be proved analytically that a wave progressing up a river must change its shape so that the front slope gets increasingly steeper, and the rear slope more gradual. If this steepening of the front slope be carried to an extreme, the wave would present the form of a wall of water, but the mere advance into shallow water would not by itself suffice to produce so great a change of form without the aid of the natural current of the river, which cooperates with this change in the shape of a wave as it runs into shallow water, so as to exaggerate the steepness of the front slope. When, as is the case for many rivers, the estuary contains broad flats or shoals of mud or sand which are nearly dry at low water, the tide sometimes rises so rapidly, especially if the mouth of the estuary be funnel-shaped, that the wave becomes a wall of water, and is then properly called a "bore." Let us note briefly the way in which Hangchow Bay affords typical circumstances of this sort, so that we there have a most striking case of this interesting phenomenon.

The Physiography of Hangchow Bay

Hangchow Bay, or the estuary of the Ch'ien-tang River, has a very marked funnel shape. From Yangtse Cape (the extremity of Pu Tung Peninsula) on the north to Ketau Point on the south is considerably over sixty miles, while the distance between banks at a point thirty miles farther west is approximately only half of this and in twenty miles more has again been reduced by half, so that along the meridian of Chapu it is only about eighteen miles wide. From Ketau Point in a line approximately northeast there extends for over eighty miles a chain of rugged islands, beginning on the south with Chusan,

by far the largest, and ending on the north in the Saddle Group, North Saddle Island being in the same latitude as the low-lying and rounded corner of Yangtse Cape. The most westward group is comprised by the Volcano Islands, which lie approximately due south from Yangtse Cape and about midway across the mouth of the bay. We shall presently refer to this group as one of the places at which definite observations of changing water-level have been made in studying the birth of the bore. Westward of this meridian the bay shoals quite rapidly in the southern half, and at times of low water, west of 121½° longitude (east of Greenwich) the mud drys for two miles from the southern embankment. It was off the northeast corner of this extensive "flat" that H. B. M. ship *Kite* was lost.

But the most marked shoaling and constriction in the figure of Hangchow Bay has yet to be noted. As already stated, at Chapu the bay is about eighteen miles wide. From this point inward the general direction of the bay is southwesterly and safe navigation ends near Rambler Island, which is about eleven miles from Chapu. Here the width of the bay for water over six feet deep has narrowed to less than five miles, and from here on inward for quite a distance the whole estuary, with the exception of a very narrow region near the northern bank, is a sandy shoal. Between Rambler Island and Haining is a range of hills forming a promontory that extends well out, making the general direction of the bay take a quarter turn and bringing it to the northwestward. On this promontory is the town of Kanpu, and a little beyond the projecting point of land and well out in the middle of the channel is a group of low tide-washed islands. Just at the western end of this turn in the northern shore is a sharp indentation, protected by a good-sized hill, which forms Bore Shelter Bay. It is at these flats and along the meridian of this hill that an observer at the Haining Pagoda gets his first glimpse of the bore.

On account of the regular recurrence of the bore, junks going from Chapu road to Hangchow take three days, and shelter first in Bore Shelter Bay and second at Haining platform. Boats drawing over three feet can not be used. The return from Hangchow to Chapu road can not be safely accomplished under three tides in any boat. Thus in spite of being situated on the main tributary of the bay of the same name, the city of Hangchow, the capital of the rich and populous province of Chekiang, the center of a great silk-producing district and of the manufacture of the best silks, being the sole source of the silk fabrics supplied to the Imperial household, and a great center of Chinese culture and literature, has practically no direct connection with the sea. There is a small canal connecting it with Haining, but practically its whole export trade passes through Shanghai

by way of the water-route we have already described. In 1905 the total trade of the port amounted to 17,496,980 Haikuan taels.[2] Our interest in these facts in the present connection lies in this: that this ancient and important city, whose population is now about 350,000, owes its very existence toward the southwest to the construction of the great sea-wall, called by the natives the "bore wall."

It is probably true that some thousands of years ago the great flat area now forming a considerable part of the province of Chekiang and Kiangsu was under water and that the Yangtse, gradually increasing its delta, reclaimed the land. The inhabitants, to assist the river in its land-forming process, built sea-walls, using the various islands as corner-stones. The wall or dyke confining the waters of the Haining-Hangchow canal is probably one of these early structures, which has better withstood the ravages of time and tide. As these walls were multiplied and extended, they caused the projecting north point formed by the alluvial deposits of the Yangtse and the Ch'ien-tang Kiang to extend seaward, thus forming the present funnel-shaped mouth of the latter river, as already noted, and obstructing to a considerable extent the progress of the ocean tide, the northern promontory deflecting it inwards and the shoals causing it to heap up into an increasingly powerful wave—the forerunner of the present bore. Against this rush of water the poorly constructed dykes were insufficient and the people along the shores of Hangchow Bay, especially on the northern side, frequently suffered great losses.

[2] A tael is about five sixths of a gold dollar and is the unit of trade in China.

THE RELATION OF COLOR AND CHEMICAL CONSTITUTION

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AMONG the many branches of scientific learning whose early development we owe to the analytical mind of Sir Isaac Newton, none can show a more beautiful discovery than that different colored rays of light suffer unequal amounts of refraction or bending when passed through a prism; and that sunlight itself by similar means is resolved into a series of colors, the order of which, beginning at the red and ending with the violet, corresponds with a gradual increase in refraction. It was this that gave us our first spectrum and proved at once the composite nature of white light.

After these discoveries by Newton, a hundred years and more elapsed before Wollaston in 1802 observed the spectrum of a ray of sunlight admitted through a narrow slit in a window-blind. In this simple experiment, which gave a better distribution of the spectrum colors than could be obtained with the pencil-like rays of Newton's time, certain black lines were seen to cross the spectrum parallel to the slit. The investigation of these lines, however, was left to Fraunhofer, who, several years later, with much improved apparatus for collecting the light rays and projecting the same upon a screen, succeeded in definitely establishing the existence of a large number of black lines in the solar spectrum. In other words, the light from the sun was shown to be incomplete by reason of the absorption of certain of its rays, as was indicated by over 700 of these dark lines. To the principal lines, still called by Fraunhofer's name, he assigned letters beginning in the red with *A* and ending in the violet with *H*.

That there also existed an invisible portion of the spectrum lying to either side of the visible spectrum, was early pointed out. Sir William Hershel in 1800 observed the great heating effect of that portion beyond the red, while Sir John Herschel in 1840 demonstrated the existence of Fraunhofer lines in this infra-red region. Ritter and Wollaston showed that silver chloride blackened readily in the invisible portion of the spectrum beyond the violet, a fact readily inferred from Scheele's observation in 1777 that silver chloride turned dark more readily in violet than in red light. E. Becquerel, however, in 1842 succeeded in identifying many of the Fraunhofer lines in this ultra-violet region and lettered the principal lines from *L* to *P* in continuation of those already lettered by Fraunhofer.

Fraunhofer had noticed that the yellow spectrum line from common salt, when fed into a spirit lamp, was identical in position with the *D*-line of the solar spectrum. But though the formation of these discontinuous spectra from various salts in a flame was generally known, it was not until 1859 that the presence of the Fraunhofer lines in the solar spectrum was clearly explained by Kirchhoff, who deduced the following law: "The relation between the powers of emission and the powers of absorption for rays of the same wave-length is constant for all bodies at the same temperature." Thus the particles of a substance under the excitement of some outside force are thrown into a state of vibration which is dependent upon the chemical nature of the substance itself. This vibratory motion gives rise to waves in the ether and we have the phenomenon of emission. Again the particles of a substance are most responsive to these same characteristic vibrations and will absorb them whenever present, just as, by analogy, the strings of a piano pick up sound waves of the exact period in which they vibrate when these waves are set in motion by other musical instruments in the neighborhood. Kirchhoff explained the solar spectrum as one produced by a strong white light from an interior sphere passing through a concentric layer of vapors of many substances, each of which absorbs those particular rays that correspond to their own periods of vibration. The light, thus deprived of many definite rays, indicated their absence when its spectrum was cast upon a screen by the appearance of dark lines—the images of the slit through which the light passed—corresponding always to the wave-lengths absorbed. It must not be assumed that these lines of absorption are regions of total darkness. The particles set in vibration by the rays absorbed will naturally give out some light of this same vibration period, but the light emitted is so small in comparison with the rays from the original source which pass through unmolested that the image cast upon the screen will give the appearance of almost total darkness.

Now when a substance is yellow in color we can readily ascertain that the spectrum of the light it reflects is lacking in a number of rays of various wave-lengths. These rays correspond to the complement of the color reflected, and in the case of a yellow substance belong to that magnitude found in the blue end of the spectrum. If no wave-lengths of the visible spectrum had been absorbed, we should have had the continuous spectrum of white light in the light reflected, *i. e.*, the body itself would not be colored. Colored substances, therefore, absorb the rays of their complementary colors and, consequently, when white light is transmitted through them their spectra will indicate the regions of this absorption by dark bands of varying intensity. The absorption spectrum coincides always with the spectrum obtained from the reflected light.

Though Fraunhofer had failed to grasp the true significance of the dark lines in the spectrum he was able to solve another highly important question—that of determining the wave-lengths to which these lines corresponded. From the wave-theory of light it may be readily understood that certain ether particles in the courses of different rays of light (*e. g.*, those of equal amplitude) may receive a strengthening or retardation in their transverse vibrations according as they fall in with the same phase of vibration or out of it. Upon this principle of interference of light as developed by Young, Fraunhofer based his method for studying and measuring the lines of the spectrum. He made what he called a grating by ruling close together a number of parallel lines upon a glass plate. When light is thrown upon this series of equal and equidistant apertures a certain amount of the light will be diffracted to either side of the direct course. Among these diffracted rays as collected by a convex lens may be found several series of bright and dark bands which correspond to the points of augmentation and retardation, respectively, of the ether particles under the influence of light from certain apertures. By simple calculation the first bright band is known to be formed when the light rays from two adjacent apertures differ by exactly one wave-length in their respective courses to this band. A ready means, therefore, is given for measuring the wave-lengths of light rays. When white light is used a number of these bright bands will occur, with the light of shortest wave-length —the violet—nearest the central image and that of the longest wave-length—the red—farthest removed. In other words, we have a spectrum, but one so constructed that a direct means is given for determining the wave-lengths of the various lines it may present. The complete map of the wave-lengths of the lines in the visible solar spectrum was published in 1868 by Ångström. The wave-lengths were expressed in ten millionths of a millimeter. Since that time they have served as a standard in all similar investigations under the name of the Ångström Unit (A.U.). One millimicron (the millionth of a millimeter $\mu\mu$) is equal to 10 A.U. The visible spectrum extends from light of about 7,600 A.U. in the red to that of about 3,900 A.U. in the violet. A more satisfactory method of expressing the results of observations in the spectrum is to use the number of waves of any particular ray of light which occur in one centimeter in vacuo, or what is called the oscillation frequency (O.F.). This is the reciprocal of the wave-lengths when reduced to vacuum values. As the reduction makes but little difference in the final value, it is usually customary to make the correction by adding one or two A.U. to the observed wave-lengths. Curves constructed from oscillation frequencies approach more nearly a straight line, and thus are easier to draw.

A few of the best known lines may be given in order to show the relation in values:

Symbol.	Color.	Wave-length. (λ)	1/λ O. F.	Frequency per Sec.
D	Yellow	0.0005893 mm.	1,696	510 trillion.
F	Blue	0.0004862 mm.	2,000	618 "
H	Violet	0.0003970 mm.	2,520	760 "

Our best modern instruments for work in the infra-red region depend entirely on the heating effect. So sensitive indeed is the bolometer, as devised by Langley, that a difference in temperature of one five-hundred-thousandth of one degree F. can be determined and, by its use in this region of the spectrum, rays of wave-length 100,000 A.U. have been detected. The study of the ultra-violet region of the spectrum depends upon the sensitiveness of silver compounds and accordingly on photographical measurements. As glass was found to absorb the rays of shorter wave-lengths than 3,300 A.U., quartz lenses and prisms must be used. Quartz absorbs rays of a wave-length less than 1,850 A.U., but fluorite may be used for rays down to a wave-length of 1,000 A.U. Air itself exerts a powerful absorption for rays of a wave-length of 2,000 A.U. and under, hence for these finer observations the apparatus must be exhausted and observations made in a vacuum. In the photographical determinations of this region the greatest care must be taken in preparing the silver bromide plates. No gelatine can be used upon the plates as it is found to exert a strong absorption for the shortest rays. The sensitive plates are usually made by precipitating silver bromide in a solution over a glass plate and allowing the precipitate to settle slowly upon this plate. When these sensitive films are colored, the plate becomes more sensitive to the rays which the dye absorbs.

The principle established by Kirchhoff was applied with intense vigor to the study of all the lines of the solar spectrum. The introduction of various substances into a flame was found to give spectra of many colored lines, but these were always definite for each and every substance examined. The lines in these discontinuous spectra were seen in many cases to have their exact counterpart in certain of the Fraunhofer lines and consequently the existence of the particular element producing them may be assumed in the solar atmosphere. In this manner, the chemical composition of the sun's atmosphere has been determined, and even new elementary substances discovered therein by the selection of certain lines or groups of lines, unaccounted for by any element previously studied. The line-spectra of many elements are readily obtainable at low temperatures, but for iron and similar metals a far higher temperature is required, as, for example, that of the arc. For gases a strongly induced electric current (one of high tension) is necessary. In the arc spectrum of iron over 2,000 lines are observed, whereas the spectrum obtained at the flame temperature consists of only a few bands and lines. At the hottest portion of the spark the iron spectrum shows the same lines as in its arc spectrum,

but in addition a number of "enhanced lines," as Lockyer has chosen to call them. By reason of these latter, Lockyer assumes that the atom of iron (as well as of other elements) may consist of more elementary constituents at extremely high temperatures, and, if the cooler vapors could be removed from this hottest zone, the enhanced lines might stand alone for the elementary form of iron—as a proto-iron. Such conditions are said to be obtained in sun spots and our hottest stars. Whether the extremely high temperature alone is sufficient to produce the enhanced lines, or whether their origin lies in the enormously rapid changes of electric stress, can not be answered at present. In either case, there seems to be no doubt but that the atom of an element consists of yet smaller particles, which, with rise of the disintegrating forces, show a marked increase in their activities, and, owing to the similarity existing between these particles, give spectral lines of greater and greater simplicity.

When a group of lines in a spectrum has oscillation frequencies that obey a single formula we call this group a series. The simplest elements usually give three series, each of which consists of lines in doublets or triplets. The action of a strong magnetic field upon the series of an element's spectrum tends to decompose the series; each line is resolved into two or three lines (doublets or triplets) according as the light is viewed along or across the magnetic lines of force. This is called the Zeeman effect. Of the three components of motion of the particles, that one which lies in the direction of the lines of force with vibrations backwards and forwards can emit no light except when viewed at right angles to these lines of force. The other two motions at right angles to the lines of force suffer a retardation and acceleration, respectively, with the result that their oscillation frequencies are similarly affected and consequently two separate lines will be developed. These may be observed by themselves when the light is viewed along the lines of force or in conjunction with the original line—with position between these two—when the light is viewed across the magnetic field. The electro-magnetic composition of the atom therefore seems to be corroborated by these results.

As an analogy to this gradual disintegration of the atom under the great stress brought to bear upon it, and further to show how the more complex molecules behave under the influence of temperature, we have only to examine the spectrum of a compound. Whatever compound is admitted into a flame, the characteristic spectrum of the molecule first makes its appearance. This consists not of lines, but of bands of varying widths. On further increase of temperature the decomposition of the compound molecule is attained, and the bands gradually give way to the characteristic lines of the elements concerned. With numerous compounds, for example, the metallic chlorides, this temperature is exceedingly low. Since the presence of spectral lines is un-

doubtedly to be accounted for by the vibrations within the atoms, we may well have recourse to the modern conception of the atom as advanced by J. J. Thomson. Here the atom is considered as made up of a central mass carrying a positive charge. Surrounding it are numerous electrons of a negative charge, the number of which increases directly with the atomic weights of the elements concerned. The electrons are undoubtedly arranged in some systematic order and may, as Nagaoki imagines, follow parallel courses closely analogous to the rings of Saturn. A disturbance of any one group or belt of electrons will undoubtedly produce a disturbance in yet other groups and, according to the amount of disturbance, the definite vibratory motions established will set up vibratory motions in the ether, later to be detected in the spectrum. From this hypothesis the spectrum of an element of high atomic weight might be expected to contain more lines than one of low atomic weight. Such, however, need not necessarily follow. If we take the case of radium, uranium, etc., we may imagine the electrons in its atom to be grouped closely together in only a few courses or belts. In fact this very hypothesis may well account for the discharge of electrons from such highly condensed arrangements and give rise to radioactivity.

From this modern standpoint the molecule is regarded as a combination between atoms as effected by the loss or gain of one or more electrons from one to the other, developing what is commonly termed "bonds of affinity" and corresponding in number to the valence of the particular atoms concerned. These may be more correctly construed as Faraday tubes of force.[1]

With these ideas in mind the banded spectra of compounds may be accounted for by disturbances induced between the atoms, as well as by small electronic vibrations set up in the atoms themselves and due to the perturbances of the Faraday tubes of force. The vibrations resulting from this composite arrangement of vibratory centers may be sufficient to extend over a considerable area of wave-lengths and thus produce a band. As the temperature increases these band spectra, always obtained with compounds, pass over gradually into the line spectra of the constituent elements concerned. There follows, then, with increase of temperature or electric stress, as has already been noted,

[1] The lines of force binding two atoms and constituting an electrical field between these charged atoms is conveniently regarded as made up of tubes of force, each with its positive electrical charge at one end, the beginning of this tube, and its negative and equal electrical charge at the other end or termination of the tube. Each Faraday tube, therefore, encloses a charge of electricity of unit value or that denoted by one single electron and consequently an atom that is univalent must enter into combination by means of one Faraday tube of force, one that is bivalent by two such tubes, etc. The positive atoms are those formed by the loss of electrons and the negative atoms are those which can take up these same electrons.

a gradual disintegration of the series of lines into simpler arrangements, caused probably by reason of a similarity existing between the ultimate constituents of our elements. This explanation is made more plausible from a study of the Zeeman magnetic effect upon similarly charged particles.

Even under the ordinarily obtainable conditions of the laboratory a great similarity may be noted between the series of lines in the spectrum of one element and the series of all other elements belonging to the same family. Thus with a gradual increase in atomic weights there occurs a corresponding gradual shifting of the series toward the red end of the spectrum. Increase in atomic complexity is ever seen to have a marked effect upon the vibratory motion of the simplest particles such that vibratory frequence is retarded. Among compounds, as well as with the elementary substances, this influence of mass is clearly shown in their spectra. Owing to the great tendency among most compounds to undergo ready decomposition when heated an examination of their spectra is restricted to the absorption spectra alone. The relations for absorption spectra having already been noted, it need hardly be further stated that the absorption bands in the spectra of compounds indicate at once the color of the compounds themselves and, what is most important of all, anything that can be brought to bear upon the interpretation of these bands and their positions should give us an insight into the cause of color as existent among compounds generally. In the examination of absorption spectra of compounds, the best results are obtained when the substances can be dissolved in some solvent which exerts but little or no absorption action for light. Among the best examples of such solvents are water, methyl alcohol (wood-spirit), and ethyl alcohol, none of which will absorb rays of a wave-length over 2,000 A.U. The absorption spectrum of a compound dissolved in a medium of this nature is identical with its absorption spectrum observed in the free state.

Among the first to obtain any positive results whatsoever in the examination of the absorption spectra of compounds was W. N. Hartley. He studied the solutions of metallic nitrates and found that the absorption in these cases was slightly modified with increase in atomic weight of the metal present, and concluded, therefore, that that portion now termed the nitrate ion—or negatively charged portion of a nitrate when dissociated by a solvent—has no effect upon the band. Not, however, until 1879, when Hartley and Huntington turned their attention to the study of absorption bands in the ultra-violet regions of the spectrum, could any hypothesis of a definite nature be formulated as regards the relation of these bands to chemical constitution. Their method of observation, which has been in use up to the present time, depended entirely upon obtaining a series of photographs of the spark spectrum as viewed through layers of a solution at varying concentra-

tions. Hartley and Huntington used a cadmium alloy, which they found to give a great number of lines, but in recent work the arc spectrum of iron has been adopted. This latter gives, as already noted, a vast number of lines extending throughout the visible and invisible spectrum in a more or less equally distributed manner. The presence of an absorption band is detected by the absence of lines in the photograph, hence the advantage of their great number and equal distribution. By successive photographs accompanying an increase in dilution the greatest degree of absorption, and thus the head of any particular band, may be observed.

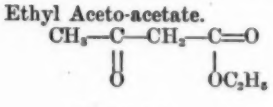
The oscillation frequencies at the edges of these bands were determined up to the point of complete transmission following the increase of dilution. The figures obtained were plotted as abscissæ against the corresponding volumes in which definite amounts of the substances were dissolved. The curved lines drawn through these points, called by Hartley the "curves of molecular vibrations," were found to be closely related to the chemical constitution of the compound studied. More recently a better method of plotting results consists in photographing through varying thicknesses of a solution of known strength and then diluting the solution ten times, repeating the observations, again diluting ten times, and so on till the point of complete transmission is reached. The relative thicknesses are now expressed in millimeters of those thicknesses that would be required of the last or most diluted solution, and these values plotted in the form of logarithms as the ordinates over against the oscillation frequencies as abscissæ. Curves thus plotted show at once the same relative shift with the ordinates as is made with the thicknesses examined. The persistence of a band, or change of concentration through which a band asserts itself, is well illustrated by this curve. In this point—the persistence—we have a characteristic function of the bands which connects them closely with chemical properties.

The compounds studied have been entirely within the realm of organic chemistry. In this class we meet with the most pronounced and, at the same time, the most easily varied tints. A study of these variations in color in the closely related organic compounds has, up to the present, occupied the entire attention of investigators, among whom, after Hartley and Huntington, are to be named Baly, Desch and Stewart.

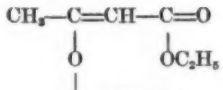
The absorption spectra in the ultra-violet region may be classified under two broad types; the first type is that in which only a general absorption is present; the second is that in which distinct absorption bands occur, a type usually defined as one of selective absorption. To the first class belongs, broadly speaking, the majority of the aliphatic or open chain compounds; to the second belongs the majority of the aromatic compounds or those of ring structure. Among the first

observations made it was discovered that an acid and its alkyl ester (esters formed by such groups as methyl, CH_3, ethyl, C_2H_5, etc.) gave identical absorption bands; a fact that pointed conclusively to the identity in molecular constitution existing between the two compounds. But among the most interesting cases bearing upon the relation of these absorption bands to chemical constitution stand the two substances acetyl acetone and ethyl aceto-acetate. We assume that each of these compounds can exist in either of two forms—one in which an oxygen atom is doubly linked to a carbon atom which bears in turn two carbon radicals and thus forms a so-called ketone; the other, where this same oxygen atom is singly linked to the carbon atom in question and has its second affinity absorbed in a hydrogen atom, thus forming a so-called hydroxyl derivative, or one usually designated by the term enolic. The two forms may be graphically represented thus:

Ethyl Aceto-acetate.

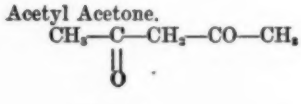


(Ketonic)

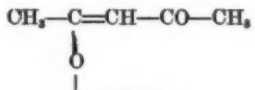


(Enolic)

Acetyl Acetone.



(Ketonic)



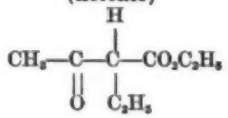
(Enolic)

Such compounds are described as tautomeric, *i. e.*, they contain a labile atom, hydrogen, which in its wandering or change of position brings into existence two distinct modifications of a compound without altering its general structure. As this change is not complete at any one instant and may vary with change of conditions, we have a condition of equilibrium always existing between the two forms. In the compounds just cited the labile hydrogen atom may be replaced by the atom of a metal and thus give what are called metallic derivatives, which from chemical evidence are supposed to exist entirely in the enolic form. Upon examination of the absorption spectra of these compounds, acetyl acetone itself, as well as its aluminium derivative, was found to give similarly banded absorption, but with that of the aluminium salt showing a greater persistence. Now ethyl aceto-acetate gives only a slight general absorption without trace of a band. Its aluminium derivative, however, gives a banded spectrum which bears a great similarity to the spectrum of acetyl acetone. Therefore, if the metallic salts are enolic, as chemical evidence strongly favors, the free ethyl aceto-acetate certainly must be ketonic.

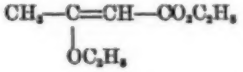
In order to investigate this matter more closely the two ethyl derivatives of ethyl aceto-acetate were examined. These compounds made by entirely different processes have different properties and corre-

spond in constitution to the two distinct forms, ketonic and enolic, of the free ethyl aceto-acetate. They may be graphically represented as follows:

Ethyl ethyl-aceto-acetate (ketonic)



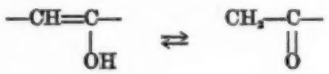
Ethyl β-ethoxy-crotonate (enolic)



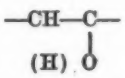
Upon examination of their absorption spectra, it was observed that the enolic compound exerts only a general absorption without a band, while the ketonic compound was practically free from absorption. This is exactly what might be anticipated from the results of Hartley, who had already shown that no difference exists between the absorption spectrum of the compound and that of its alkyl (here ethyl) derivative. Even a mixture of these two alkyl derivatives fails to show the presence of absorption bands in the spectrum. We may conclude, therefore, that an absorption band is not to be attributed to either the one or the other form of a tautomeric substance, but rather to the changing of one form into the other—a dynamical isomerism. If this intramolecular transformation is the source of the disturbance which produces the absorption bands, then an acceleration of this transformation should show itself in the increased persistence of the band, while retardation of the same should diminish this persistence. For some time it has been known that alkalies exert a marked positive influence upon the velocity of tautomeric changes and, as may be naturally inferred, acids retard this change. On the addition of a small amount of sodium hydroxide to a solution of ethyl aceto-acetate, the form of the absorption-curve changes at once and a band appears. On the further addition of alkali, the depth of this curve, that is the persistence, increases until it reaches a maximum corresponding to the presence of a large excess of alkali. The absorption-curve of the aluminium derivative of this ester has not the persistence of that of the sodium salt when the sodium hydroxide is present in excess of one molecular equivalent. With the addition of hydrochloric acid a retarded action is developed and even the absorption curve for the free ester is seen to diminish slightly in its persistence when an excess of acid is present, indicating, therefore, that the free ester is not entirely ketonic, but is in equilibrium with a very small quantity of its enolic modification. Spectroscopic evidence points out that the persistence of the absorption bands over concentration changes is directly proportional to the number of molecules in the state of oscillation or, in other words, is a measure of the dynamical isomerism between substances in equilibrium with each other.

From these considerations it is evident that this dynamical isomer-

ism must be closely connected with some peculiar vibration or free period synchronous with the oscillation frequency of the light rays absorbed. The oscillation frequency, however, is about the same for all the substances just examined and lies between the limits 3,600 and 3,800, no matter what the labile atom may be. We are, therefore, forced to the conclusion that the absorption bands can not be due directly to this oscillating labile atom, or, in other words, the vibration frequency of this atom is not identical with the oscillation frequency of the light absorbed. This inference is strongly substantiated by physical evidence which represents atomic motion as far less than that of this magnitude of light rays. There remains then but one final solution of this question, or the conclusion that the absorption band is due directly to the change of the linking which accompanies the wandering of the labile atom. In the case of the keto-enol tautomerism just discussed, we may represent the change graphically as follows:



At some stage in its transformation the hydrogen atom must have wandered to the half-way point of its journey and have been linked definitely to neither the carbon nor the oxygen atoms. We should then have the phase in which the carbon and oxygen atoms change linking.



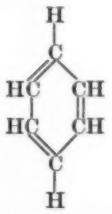
By the examination of countless numbers of organic compounds it is found that absorption bands in the ultra-violet region of the spectrum are shown only by compounds exhibiting some form of tautomerism, whether this be due to the keto-enolic type or to a periodic type, like that present in ring compounds. The oscillation frequency of the light absorbed in all cases of keto-enol tautomerism is about the same, but with an increase in the mass of the molecule as brought about by the displacement of one atom by a second atom or group of atoms of greater relative weight, a decrease in the oscillation frequency is observed. This displacement, however, is only small and does not interfere with the general assumption that there is present some condition common to the whole group upon which the absorption directly depends.

From the standpoint of modern theories regarding the structure of the molecule, there must arise in this tautomeric change a constant making and breaking of the Faraday tubes of force. This means a constant disturbance of the electron systems and, consequently, similar vibrational disturbances in the ether. From Hewitt's studies in fluorescence these electronic disturbances, due to dynamic isomerism,

appear to be of the same order as light waves and, consequently, by absorption of their wave-lengths white light should show the absorption spectra we have noted. The sodium and aluminium derivatives of ethyl aceto-acetate may be described as equilibrium mixtures of the enolic and ketonic forms. The fact that the sodium salt is so easily hydrolyzed in an aqueous solution need not enter into the discussion of the absorption spectra. The evidence in all these cases goes to show that the metallic ion still exerts its influence and does not lead an altogether separate existence from that of the negative ion. Accordingly we may regard the Faraday tubes of force as stretched, but not necessarily broken, by the action of the solvent. On this basis, an ionizing solvent is to be considered as one that will bring about this lengthening of the Faraday tubes. Among the best examples, we may cite water, liquid sulphur dioxide, and liquid ammonia, or those substances which possess in reality a certain amount of " residual affinity "—affinities that may yet be exerted. Tautomeric changes in solution receive their interpretation, then, in the lengthening of the Faraday tubes of force to that point where the labile atom comes so far under the influence of a neighboring atom that a break occurs, which in turn gives rise to the oscillatory disturbances already discussed. With tautomeric compounds in which the labile atom has been replaced by an alkyl group there is absence of tautomerism due to the non-formation of alkyl ions, in which case it is seen that water and alcohol have not sufficient power to lengthen the Faraday tubes of force. The persistence of an absorption band may be defined now as the measure of the atoms in this transitorial state or the measure of the extent to which the labile atoms are separated from the molecule proper. Wherever the tautomeric compounds display the phenomenon of fluorescence a second free period of vibration is present. The latter must depend upon the former since a compound does not fluoresce except when exposed to light rays of the frequency of the first free period. Recently it has been demonstrated that a fluorescent substance gives two bands in its absorption spectrum, one for each of these periods of vibration. The band from the incident light is well marked, but the band from the fluorescent light is so faint that it can be made fairly visible only when the light of the first free period is strengthened; a fact that substantiates the dependence of the second free period upon the first.

As the origin of absorption bands in the ultra-violet spectrum have received an explanation in the change of linking brought about by the shifting of a labile atom, so clearly represented in the examples of keto-enol tautomerism, we may rightly expect to find absorption bands in the spectra of other compounds in which some change of linking is exhibited. No more beautiful example can be found than that of the compound known as benzol, where six carbon atoms, unchangeable in their order, are bound together in a single ring. To each carbon is

attached an atom of hydrogen, but as carbon is usually considered quadrivalent, a fourth seemingly unused bond of affinity remains free to each of these carbon atoms. This affinity may be considered as the residual affinity. To this substance Kekulé has assigned the structure illustrated by the graphical formula:

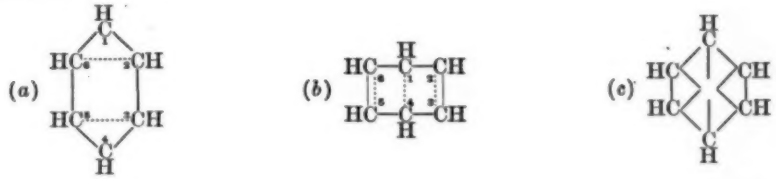


The introduction of three double linkings between the alternate pairs of carbon atoms satisfies the demands for quadrivalence in these atoms. But Kekulé clearly called attention to the fact that a sort of equilibrium existed between all the carbon atoms, such that the presence of one of the three double linkings between any two adjacent carbon atoms, when both were involved in the formation of a derivative, would not necessarily change the properties of the derivative from that one formed when two adjacent carbon atoms were united by only a single bond. Now the Kekulé formula, and in fact all the older formulæ assigned to this compound, represent only particular phases in the motions of the molecule. The space-formula proposed by Collie,[2] in which the atoms are represented as in a state of continual vibration, serves well for the basis of our modern conception. Upon examination of the absorption spectrum of benzol we note the presence of seven distinct bands all quite similar and closely situated with reference to each other, appearing between the oscillation frequencies 3,725 and 4,200. These bands are in that part of the ultra-violet spectrum where the absorption bands due to keto-enol tautomerism displayed themselves. At once the idea of a similar make-and-break of linkings between the carbon atoms suggested itself, and, in exact accordance with this hypothesis, the seven distinct bands may find here their cause of formation.

In keto-enol (aliphatic) tautomerism an even number of carbon atoms is always involved in the make-and-break of linkings. Accordingly with the benzol molecule we may assume that two, four or six carbon atoms may enter into this phase at one time. If the carbon atoms are numbered consecutively from 1 to 6, we should have in order the following conditions which represent the change of linkings between certain numbered carbon atoms: (1 and 2), (1 and 3), (1 and 4), (1 and 2, with 3 and 4), (1 and 2, with 3 and 5), (1 and 2, with 4 and 6), (1 and 2, with 3 and 4, with 5 and 6). At the outset we shall suppose the benzol ring to be elastic and capable of under-

[2] *Chem. Soc. Trans.*, 71, 1013, 1897.

going various pulsations, such as may be illustrated by the accompanying figures:



The dotted lines show the linkings developed from the free affinities when the ring is pulsating between the two forms (*a*) and (*b*). The centric formula for benzol (Baeyer's), as shown in (*c*), may be, therefore, an intermediate form for all the possible forms. The free or residual affinity possessed by each carbon atom asserts itself under the various conditions which can be brought into existence by these pulsations, with the effect that the several linkings produced must involve always a pair of carbon atoms and then in turn during the second stage of the pulsation must suffer a break and consequently give rise to some particular one of the seven possible phases, with its characteristic absorption band of course depending upon the carbon atoms in question. Altogether, when the entire ring is free to pulsate in every direction, there will arise seven absorption bands which represent the seven possible combinations of linking-change.

The derivatives of benzol may be expected to show some variation in type and manner of pulsation from that of the parent ring, but whatever changes occur the effect upon the characteristic absorption spectrum of the original molecule will always indicate the exact nature of each change. In this connection it will be well to consider a few of the more important derivatives, which, as is generally known, are primarily formed by the replacement of one or more of the hydrogen atoms by an equivalent atom or group of atoms—a process called substitution. The alkyl radicals (methyl, ethyl, etc.) stand as a type of the neutral groups and consequently, when they are present, little change in the spectrum of the original substance should be observed. The spectrum of toluol, $C_6H_5 \cdot CH_3$, ethyl benzol, $C_6H_5 \cdot C_2H_5$, etc., are almost identical, but only the first two absorption bands of the original benzol spectrum are well marked, the remaining bands having fused more or less into one broad band. With aniline, $C_6H_5NH_2$, where the basic unsaturated amido-group (NH_2) has replaced the hydrogen atom, we get only a broad absorption band caused, no doubt, by the residual affinity of the nitrogen atom which binds or holds all the free affinities of the benzol ring. Upon the addition of an excess of hydrochloric acid to aniline, we obtain the saturated compound known as aniline hydrochlorate, $C_6H_5 \cdot NH_3Cl$, the nitrogen having passed from the trivalent to the quinquivalent state. This compound, as

might be anticipated, gives an absorption spectrum resembling very closely that of the mono-alkyl derivatives of benzol just mentioned.

The absorption band of phenol, C_6H_5OH, differs from that of the mono-alkyl derivatives in that one pronounced band has replaced the two prominent bands in the spectra of the latter. In the case of anisol, $C_6H_5 \cdot OCH_3$, the methyl derivative of phenol, known as an ether, the two prominent bands are again in appearance. In other words, the substituting group methoxyl (OCH_3) partakes more of the nature of a saturated alkyl group, whereas the hydroxyl group (OH) acts very differently. By a close examination of the two bands from anisol and the one from phenol we see that the transmitted portion, or that portion which serves to divide the one band into two, lies between the oscillation frequencies, 3,640–3,655. This is exactly the region where the absorption bands due to keto-enol tautomerism make their head. In other words, the presence of just such dynamical isomerism as may be caused by the wandering of the labile hydrogen atom of phenol will account for this absorption band and its position in overlying the regular bands due to phenolic structure, as shown in the case of anisol, etc. That a condition of dynamical isomerism is really present in a free phenol is further proved by the shifting of the absorption band to the left upon the addition of sodium hydroxide to its solutions; a result always observed in keto-enol tautomerism. Upon the bands formed by anisol the addition of alkali has no effect. On the other hand, the addition of hydrochloric acid to a phenol retards this tautomerism and when large excess of the acid is used the transmitted portion of the spectrum or that which is due to the free benzol nucleus begins again to make its appearance. The spectrum observed in the case of nitrobenzol, $C_6H_5 \cdot NO_2$, and other derivatives, where the substituent possesses marked residual affinity (due here to the oxygen atoms) shows only a general absorption. This condition, therefore, is brought about when the active residual affinity of the new groups restrains or locks up the free affinities of the benzol ring and thus retards its internal motions.

As with the mono-derivatives of benzol, so also with the disubstituted derivatives, the general rule holds true; wherever the substituents are groups well saturated, they will exert scarcely any retarding action upon the pulsations of the original molecule. The disubstituted derivatives are classified as ortho, meta and para, according as the groups are adjacent, once removed, or twice removed (diametrically across the ring) respectively, from each other. The para compounds give a spectrum more closely resembling that of the parent substance, benzol, and hence may be said to be the more symmetrical arrangement, or that which accords best with the even or symmetrical pulsations of the benzol molecule. With the ortho- and meta-compounds we may say that the unsymmetrical loading of the ring operates against the even

pulsations and tends to produce irregular vibrations which give rise to less distinctive absorption bands.

In aliphatic, as well as in aromatic, compounds, we often observe that a certain amount of residual affinity lurking in the oxygen atoms can exert a strong influence upon an entire group of atoms. One of the simplest and most reactive combinations in which oxygen may be found is that known as the carbonyl group (CO), which, when occurring between two carbon radicals, constitutes a ketone as we have already noted. The simplest ketone is acetone, $CH_3 — CO — CH_3$. The additive capacity of this carbonyl group for various reagents is well known, but this capacity very often decreases in power with an increase of the molecular aggregation in the near vicinity. For example, the additive capacity of the carbonyl group in the compound methyl-ethyl ketone, $CH_3 — CO — C_2H_5$, is usually less than that in acetone. These and similar facts have been explained upon the hypothesis of "steric hindrance" for lack of a better phrase. Though at times this hypothesis may best explain some of the intricate problems, still it hardly dare be supposed that the paths of intra-molecular vibration of the atoms is other than large in comparison with the size of the atoms themselves; consequently, slight increase in the mass of the substituents should have no appreciable effect upon the activity of a neighboring group. Oftentimes it was found that very large substituents increased the additive capacity of a carbonyl group. Thus when one of the hydrogen atoms of acetone is replaced by a carbethoxyl group ($COOC_2H_5$), a group formed by the replacement with ethyl of the hydrogen atom in the regular organic acid group, carboxyl (COOH), we get a great increase in the activity of the original carbon group. The compound so formed would have the formula, $CH_3 — CO — CH_2 — COOC_2H_5$, *i. e.*, ethyl aceto-acetate—the very same compound as was studied with reference to keto-enol tautomerism. An explanation of the increased activity in this case from the standpoint of dynamical isomerism which may be present seems to be most adequate. The oxygen atom exists temporarily in the enolic (OH) stage and the hydrogen atom, at the moment of departing, must leave the oxygen atom and consequently the carbonyl group nascent, *i. e.*, in an exceedingly active form, similar here, no doubt, to the state acquired by ionization in solution. Again the hydrogen atom itself at the moment of separation would be most susceptible also to chemical action.

In order to get an idea of the relation of this carbonyl group to the carboxyl group, one of the simplest compounds which exhibits this arrangement was studied. The example taken was the ethyl ester of pyruvic acid, $CH_3 — CO — COOC_2H_5$. Here there was observed an absorption band lying much nearer the red end of the spectrum than that obtained in the case of ethyl aceto-acetate. The band had a head at about the oscillation frequency 3,100, whereas the band of the latter

had a head near the oscillation frequency 3,700. As the molecule is lighter than that of ethyl aceto-acetate, we should, from previous observations, expect the band to be shifted farther from the red; the opposite, however, is true and the only explanation that seems possible is that the band is the result of a new kind of vibratory motion arising between two carbonyl groups when in close proximity to each other. In order to substantiate these conclusions other derivatives containing two carbonyl groups were studied. But as the carbonyl group in carboxyl has not all the characteristics of a true carbonyl group, attention was turned to the compound diacetyl, $CH_3 - CO - CO - CH_3$. Here the absorption band occurs at the oscillation frequency 2,400 (wave-length 4,170 A.U.), which is in the visible blue region of the spectrum, and hence this absorption of colored rays must result in the compound itself taking on the complementary color—that of yellow. In the same way it can be shown that glyoxal, $OHC - CHO$, gives an absorption band in the visible blue region, and consequently its distinct yellow color may be explained. Oxalic acid, $HOOC \cdot COOH$, however, with a hydroxyl group next to each carbonyl group and therefore analogous to pyruvic ester, gives no band in the visible spectrum, and is, therefore, colorless.

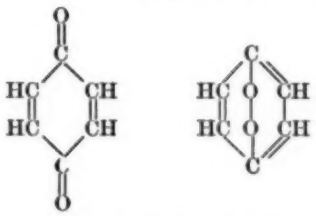
Upon the theory that a change in linking produces the absorption bands, the only possible explanation would be indicated as follows:

The make-and-break contact between the oxygen atoms would give marked activity to these atoms. Such a process other than tautomerism, where a wandering of a labile atom is suggested, has been named by Stewart and Baly[3] "isorropesis" (equipose), and differs from the former in that the head of its absorption band lies much nearer the red end of the spectrum or almost in the visible violet region. With the diketone known as benzil, $C_6H_5 - CO - CO - C_6H_5$, an absorption band with head at the oscillation frequency 3,900 was noticed in solutions of small concentrations. This would seem to indicate the presence of a certain amount of oscillation due to the benzol nucleus. The residual affinities of the two carbonyl groups are undoubtedly fixed, to some extent, by the free affinities of the benzol molecule, but even so there may be present a small amount of isorropesis between the two carbonyl groups. That such is really the case is demonstrated in solutions of greater concentration by the presence of a very shallow absorption band with head at the oscillation frequency 2,650. Its shallowness, however, argues for only a slight isorropesis; indeed the color of benzil, which is but faintly yellow, may be made to disappear entirely

[3] *Chem. Soc. Trans.*, 89, 498, 1906.

upon dilution of its solutions, a fact confirming the spectroscopic evidence of oscillations due to benzol structure in solutions of small concentration. The presence of isorropesis, here brought about by two carbonyl groups in juxtaposition and indicated, as we have seen, by vibratory frequencies in the ether of longer wave-lengths than those due to keto-enol tautomerism, stands out at once as the source of color in chemical compounds. Again we note that the more pronounced this isorropesis the more active chemically are the groups undergoing the disturbance. The additive capacity of benzil is markedly less than that of diacetyl.

Among the compounds which furnish us with examples of this nature, or substances in which two carbonyl groups can come under the influence of each other, we may mention the most important of all, that of para-benzoquinone. This quinone is a derivative of benzol in which two oxygen atoms are located in the para-position to each other. In order to satisfy the bivalence of the oxygen atoms, the para carbon atoms are regarded as having their free affinities absorbed in these oxygen atoms, leaving the remaining carbon atoms to arrange their free affinities in two pairs of double linkings (according to the Kekulé hypothesis). It may be, however, that the second affinity of each oxygen atom will assert itself in a linking between these two atoms and therefore leave the characteristic benzol nucleus undisturbed. The two forms may be graphically shown as follows:



Now it has been proved chemically that para-benzoquinone can exist in each of these two forms. We have then just such an example of making-and-breaking as has been indicated in isorropesis, but in addition a change in the manner of linkings in the molecule accompanies this process. The absorption spectrum of para-quinone gives a band with its head at the oscillation frequency 2,150, one almost identical with that obtained from other ring compounds, *e. g.*, camphorquinone, where two carbonyl groups are adjacent. From a study of the pulsations of the benzol ring the para-positions have been shown to be closely related, and in fact so well brought under the influence of each other as to be considered as practically adjacent. Since the position of the absorption band is in the blue region color must, of course, be present in this substance. Simple quinones usually show a yellow to an orange color. This color is undoubtedly due to isorropesis and whenever we have this class of substances—known as quinones—

as the base of various derivatives, we have a right to look for this same influence between the unsaturated groups, or that condition which gives rise to isorropesis and hence to color. A great portion of the coloring products known have just this sort or structure and the origin of their colors, therefore, may receive the interpretation indicated.

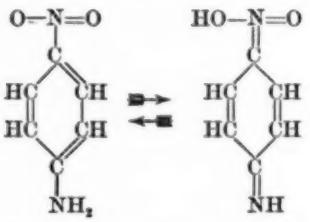
For many years the color theory proposed by Witt has been the basis of all chemical investigations in this domain. Here it is supposed that the color of an organic compound depends upon the presence of an atomic group known as a chromophore, such, for example, as the nitro group (NO_2), etc., and the introduction of more and more of these groups into a compound produces a gradual increase in depth of color. The various radicals with their respective color-giving groups are known as chromogens; upon union of these with other radicals of an acidic or basic character, we arrive at the conditions for coloring products or dye-stuffs. Now the carbonyl group alone does not appear as a pronounced chromosphere, but when two carbonyl groups, as in the ortho- or para-position in the benzol ring, are present one of the best of chromophores is developed. From such results as these Armstrong was led to believe that the particular linkings present in the benzol ring when two carbonyl groups were para to each other might account for the pronounced color reaction shown by these compounds. He characterized this type of structure, wherein the para carbon atoms have double linkings with the oxygen atoms as "quinonoid" (quinoïd), in contradistinction to that of the alternate double linkings in a benzol ring or "benzenoid" (benzoïd). Eventually, he came to the conclusion that color in an organic compound depends upon the presence of this quinoïd arrangement. From the chemical standpoint Armstrong had advanced upon solid ground. The real insight, however, into the relative value of one arrangement over that of another, as to their respective powers of light absorption and consequently of color production, must rest upon spectroscopic evidence. For example, we have seen that double linkings in themselves do not possess any power for light absorption. Their mere presence, therefore, can not account for color in a chemical compound, but if by their presence some form of oscillation is produced, we may expect the establishment of definite vibrations in the ether, which will be possible of detection in the spectrum. In compounds of the quinoïd type the conditions are precisely those that will produce vibrations in the ether corresponding in wave-length to portions of the visible spectrum, consequently the appearance of color. In compounds of the benzoïd type alone the oscillations correspond to vibrations of such frequencies that they fall in the ultra-violet region of the spectrum, and hence such compounds will be free from color. The oscillations which exist whenever the quinoïd type of compounds is concerned, and which distinguish this type from that of the benzoïd, must be due to the oxygen atoms in

the para-position. Now the activity of these oxygen atoms is to be attributed to the residual affinity which each is known to possess, and hence by the assertion of this affinity when in close proximity to each other, followed quickly by a break in the same, we arrive at the condition known as isorropesis, upon which form of oscillation the color depends. It is necessary in this process that the active groups undergoing isorropesis should be adjacent. The pulsations of the benzol ring readily furnish the means by which the two para-atoms are successively brought under the influence of each other, and hence their positions will approach more nearly to that of adjacent atoms, a point that was confirmed by the similarity in the absorption spectra between para-benzo-quinone and compounds where the two carbonyl groups were actually adjacent. The study of ortho-quinones falls in the same category as the para-quinones and may be explained in a similar manner. Meta-quinones, however, can exist, but momentarily on the hypothesis of the benzol pulsations and hence are unstable.

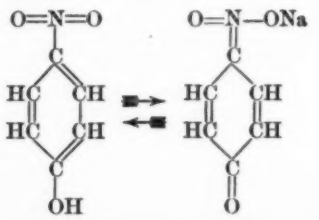
Isorropesis, as has just been indicated, occurs between adjacent atoms possessing residual affinity. It is also to be remembered that some disturbing force must be brought to bear upon these atoms, for otherwise no make-and-break and consequently no oscillation can take place. In the simplest case studied, that of diacetyl ($CH_3 — CO — CO — CH_3$), the disturbing influence rests undoubtedly with the hydrogen atoms of the methyl groups which from their electro-positive nature exert a strong attraction for the electro-negative atoms of oxygen. This constitutes a sort of keto-enol tautomerism, the presence of which should certainly be accounted for in the appearance of the absorption-curve; indeed, the slight extension of the absorption-curve of this compound near the oscillation frequency 3,800 corresponds exactly to the location of a band due to keto-enol tautomerism. The cause of isorropesis in a compound rests, then, upon the disturbances of the residual affinities of the two atoms in juxtaposition. In the examples already cited, those of pyruvic acid and oxalic acid, the hydroxyl group is next to the active carbonyl group. The slight positive nature of the hydrogen atom in this capacity will diminish its disturbing effect upon the second oxygen atom, or that of the carbonyl group, and consequently only the slightest amount of isorropesis will be possible. With the alkyl ester of pyruvic acid the conditions will favor a slight isorropesis, as we have seen, but with oxalic acid there should be none at all. In quinones the residual affinities of the benzol ring constitute the disturbing factors. The hydrogen atoms of the benzol molecule may also exert some disturbance. In general, we may say that the amount of isorropesis must rest upon the disturbing influences which can be brought to bear upon the active groups showing residual affinity, or those susceptible of this new kind of oscillation.

Isorropesis need not always be confined to residual affinities between

two oxygen atoms. Other unsaturated atoms may show similar reactions. Thus the nitro-anilines, $H_2N-C_6H_4-NO_2$, give an absorption-curve similar to that of para-benzoquinone. Here the residual affinities of the nitrogen atoms are disturbed by the motions of the benzol molecule. And, in addition, the unsaturated oxygen atoms of the nitro-group are disturbed by the hydrogen atoms of the amido-group (NH_2). These facts, together with the position of the absorption band, point unmistakably to isorropesis, and the two distinct forms thus in equilibrium may be represented by the following figures:



A solution of nitro-aniline in hydrochloric acid gives a colorless solution showing no trace of absorption band to indicate isorropesis. The structure of the hydrochlorate, therefore, is purely benzoïd in type and enters not into the quinoïd form by reason of the saturation of both nitrogen atoms. In the case of the nitrophenols similar reasoning may be followed. The absorption band of para-nitrophenol, $O_2N-C_6H_4-OH$, in neutral alcoholic solution, is identical with that of para-nitroanisol, $O_2N-C_6H_4-OCH_3$, the methyl ether of this phenol. Consequently their structures may be assumed to be identical. When the phenol, however, is converted into the sodium salt its absorption-curve alters and a band similar to the band of nitro-aniline appears in the visible blue region of the spectrum; in other words isorropesis has been brought about with the natural consequence—the appearance of color in the compound. The hydrogen atom of the free phenolic group (OH) is seen to be but slightly affected by the residual affinities of the oxygen atoms of the nitro-group; the more electro-positive sodium atom, however, shows a greater activity and may be drawn over to one of the oxygen atoms of the nitro-group, and thus a quinoïd type of linking established. In the equilibrium between



these two forms we may unquestionably look for the conditions which underlie the formation of color in the salts of nitro-phenols. The

colorless free nitrophenols present only the regular form of vibration known to the benzoïd structure and hence can give no oscillation of a frequency low enough to produce color. In the salts of these phenols, however, the quinoïd type is developed and, though always in equilibrium with a certain amount of the benzoïd type, isorropesis will be present to an extent dependent upon the degree of unsaturation of the atoms, and indicated by the appearance of color. In the case of meta-compounds a measure of the persistence of their absorption bands indicates a smaller amount of isorropesis and consequently they will be less colored than the ortho- and para-derivatives. In all of these investigations care must be used in the selection of a proper solvent. Since water is known to possess a large amount of residual affinity its action upon the ethers of nitro-phenols will be quite apparent. Alcohol serves the purpose here because it is well known to exert little or no ionizing action upon ethers and esters. In general, the new free period of oscillation—isorropesis—may be represented by the equilibrium:

These are conditions which accord entirely with certain known chemical facts.

In compounds of the benzol structure the cause of color begins with the particular vibrations of the molecule itself. These oscillations, however, as has been seen, are synchronous with light waves of a very high frequency and give rise to absorption bands in the ultra-violet region only. When some other influences can be brought to bear upon these movements, as, for example, the introduction of a potential keto-enol tautomerism, isorropesis is established and the oscillations, which are now of a less frequency, may be low enough to show the beginning of color. When the retardation of these oscillation frequencies is continued, as, for example, by the introduction of heavier atomic complexes for the simpler and lighter hydrogen atoms, the absorption curves due to oscillation will gradually be made to travel toward the red end of the spectrum and the color, naturally, will travel into the blue. A very well-known example of this is the increase in depth of the blue color possessed by certain dyes which accompanies an increase in the number of methyl groups introduced into the molecule. The introduction of a chromophore group, one of a more or less unsaturated nature, may in this light be considered as among the best to push back the oscillation frequency. But with reference to the powerful effect these chromophore groups have upon the retardation of the pulsations of the molecule and the consequent establishment of a new type of linking always in equilibrium with that of the original nucleus, the interpretation of their influence seems best explained in the production of an entirely new, free period of vibration—isorropesis—within the

molecule itself. Now the term isorropesis is used to define the oscillation that takes place between the residual affinities of atoms in juxtaposition. The idea, however, may have already presented itself that in the case of the benzol structure the presence of keto-enol tautomerism with its particular period of vibration together with the oscillations occurring in the benzol nucleus, might, by a mutual combination of these two periods, give a period of greater wave-length and thus coincide with light rays in the visible region of the spectrum. If this were true, then these two conditions just stated might be looked upon as potential color systems. The actual presence of the conditions for isorropesis in the aliphatic series argues most strongly for the same sort of oscillation in the aromatic series wherever circumstances are favorable for its existence. In fact it seems highly probable that its presence alone will account for all the color-formations in the aromatic series. Other vibratory centers may exist and in fact do exist in the various compounds, but their presence only influences the amount of isorropesis that can take place and does not altogether destroy this particular form of oscillation.

In the quinoïd type of compounds the actual existence of the two distinct modifications which underlie isorropesis has already been shown. The change of one of these forms into the other and *vice versa* necessitates a change in manner of linking throughout the molecule which accompanies the oscillation in question. The fact that no one arrangement of atoms, no matter what their method of linking, can be made to show an absorption band is sufficient in itself to argue for the make-and-break in the two forms of the quinone as the cause of the color that exists among members of this class. For many years the quinoïd linking has been supposed to be the source of color in compounds of quinone formation. It was not until recently, however, that Gomberg has been able to prove conclusively that the quinoïd type of linking actually exists in colored compounds of this nature. Not alone the presence of the quinoïd type, but also the benzoïd type has been shown to be present. In fact he has been able to interpret the conditions which determine the equilibrium always existent between these two forms and thus has succeeded in establishing by purely chemical means the amount of quinoïd formation and consequently of isorropesis possible among aromatic derivatives. The spectroscopic evidence, therefore, on the existence of just such a type of oscillation as may be present in equilibria of this nature is corroborated. Upon the amount of isorropesis shown—a factor always dependent upon the relative unsaturated condition of the atoms coming into juxtaposition—we arrive at the depth of color in any given equilibrium. The presence of other groups may augment or retard the influence of these unsaturated atoms undergoing isorropesis, and consequently the corresponding variations in the oscillation frequency

will be indicated by similar variation in the nature of the color. In many ring compounds where no such arrangement of linkings, as in the benzoïd and quinoïd classes, is seen, almost no evidence of color can be found. Furfuran, pyrol, camphor and many others of a constitution exhibiting double linkings show only general absorption in their spectra. But whenever the benzoïd type is present, no matter whether the ring be composed entirely of carbon atoms or not, the conditions for isorropesis are at once favored so soon as unsaturated atoms or groups can be introduced. These groups by their unsaturated condition give rise to new linkings and then in turn undergo the make-and-break characteristic of substances showing selective absorption.

Indeed we come to the conclusion that isorropesis is the cause of color in the aromatic series as well as in the aliphatic series. In both series the two modifications which must always be *in statu nascendi* have actually been shown to exist. The change of linking, therefore, that must accompany the transformation of one into the other is certainly to be considered as the source of the oscillations which give rise to vibrations in the ether of a free period corresponding to those in the visible region of the spectrum, and hence the development of color in the substance. The application of these ideas to the interpretation of color among inorganic compounds is yet to be made. There seems, however, no doubt but that, where residual affinity exists, there may arise some form of oscillation, caused by the make-and-break of these induced linkings as brought about by the molecular movements, which will record itself in definite vibratory motions of the ether and consequently, if these vibrations are of low enough frequency, will indicate color in the compound. Not until something of a more definite nature is known as regards the true spatial arrangement of the atoms in these compounds, can anything of positive value be postulated concerning the disturbances which certain atoms may bring to bear upon other atoms or groups of atoms in the molecule. Consequently the periods of oscillation that correspond to many of our well known colored salts have received no explanation in terms of those periods so definitely established among the carbon compounds; periods which through spectroscopic evidence have been made to reveal so much concerning the internal vibrations of the atoms in the molecule and of the disturbances within the atoms themselves.

GERMAN INFLUENCE IN LATIN AMERICA

By ALFRED F. SEARS, C. E.
PORTLAND, ORE.

I. *Magnitude and Character of German Immigration*

IN 1901 the American citizen was startled by the information from Rio Janeiro, that "A German syndicate has just been formed with a capital of 25,000,000 Marks, with the object of colonizing in Brazil, the states of Rio Grande do Sul, São Paulo, Santa Catarina, Paraná, Minas Garaes and Goyas. The government has guaranteed 5 per cent. interest on the investment in the enterprise."

At about the same time a further statement was published to the effect that the powers of Europe are combining to overthrow our formidable Monroe doctrine, through a society recently organized in Rome for colonization by Italians in various sections of Brazil.

American newspapers declared "the German problem in South America to have been brought sharply to the attention of the national administration by this despatch" made the subject of editorials more or less intelligent all over the land. Some of the newspapers were sufficiently sane to offer their readers definite figures on which to base judgment of American duty. Generally, the patriotic bias developed but little jingoism in the complacent American press. Washington, from the heart of things, assured the nation that Germany is our firm friend, innocent of all design against the bogie we have raised on our neighbors' towers.

While the passion of suspicion concerning the Kaiser's intention was yet alive, the writer was in South America to execute a scientific commission. He had previously spent sixteen years of active professional life in Mexico, Central and South America and believed that he could serve the interests of his country and the impulse of an improved civilization by presenting data for the intelligent consideration of questions involved in foreign colonization schemes among our southern neighbors and illustrating the results to be reached by Teutonic influence among the elements of Latin American life, now so grossly amalgamated with aboriginal barbarism, the slave and tool of Spanish medieval ecclesiasticism, which breeds and fosters social and political immorality.

With this end in view, he addressed a circular to official representatives of all the republics in these continents, soliciting a statement of:

1. How many Germans are settled in the states represented by the officer addressed?

2. Are they settled in collected colonies or scattered over the country?

3. Are they generally engaged in agriculture or in other pursuits?

With this circular a blank form for reply was enclosed, covering all necessary ground for securing a comprehensive description of the condition of German colonization in Latin America.

A general cordiality was encountered among members of the diplomatic and consular services in giving the information at their command, so that reports, more or less definite, were received from every one of the republics. They are here presented in tabular form to aid in a study that shall reach a fair understanding of one of the most important problems facing the American people; one that will appear the crucial problem of the twentieth century. It concerns the enfranchisement of 60,000,000 human beings, the inhabitants of this western hemisphere, and their consequent entry into a superior civilization.

The tabulation proceeds from Mexico, our nearest neighbor, to the most remote state of the southern continent, preserving thus a correct spectrum of the geographical relations.

These figures will be a revelation to the alarmist, apprehensive that Latin America is being submerged beneath a German population

Names of Republics.	Area in Square Miles.	Total Population.	No. of Germans.
Mexico	800,000	14,000,000	2,000
Guatemala	47,000	1,600,000	6,000
Honduras	43,000	420,000	50
Salvador	7,000	1,000,000	1,000
Nicaragua	52,000	420,000	600
Costa Rica	20,000	310,000	340
Colombia	331,000	5,000,000	150
Venezuela	566,666	2,500,000	3,000
Brazil	3,200,000	18,000,000	1,000,000
Ecuador	144,000	1,500,000	300
Peru	405,000	4,000,000	3,000
Bolivia	472,000	2,500,000	400
Uruguay	72,000	1,000,000	765
Paraguay	145,000	600,000	916
Chile	257,000	3,000,000	15,000
Argentina	3,100,000	5,000,000	17,143

devoted to monarchism. We find 1,051,000 Germans spread over an area of 8,000,000 square miles of territory, already occupied by a native population of more than 60,000,000, who have secured through war their independence of foreign domination, which they show a disposition to guard with jealous watchfulness.

In the comments appended to their reports by consuls and ministers there is the unanimous agreement that German immigrants constitute

a most desirable class of citizens. The reader will observe that the mass of German immigration has settled in the temperate zones of the continent, avoiding the tropics. Thus we find 32,000 or more are colonized in Chile and Argentina, regions extending as far south as forty degrees from the equator, while the Brazilian colonies of São Paulo, Paraná and Rio Grande do Sul are in the south of the republic, extending to thirty-five degrees below the equator and containing the mass of the German population, though there are some thousands in the tropical state of Minas Geraes lying between fourteen and twenty-three degrees south of the equator, a mountain mining region, where altitude supersedes latitude in the comfort of temperature.

There is no considerable condensation of Germans in colonies, save in Brazil, Chile and Argentina, there being but 20,000 of them distributed among the other thirteen states of the continent. These people are generally engaged in commerce and trade. In the commercial cities the jewelry business and that of money exchange are almost universally conducted by Germans, generally Jews, who, when not so engaged, are devoted to some other branch of city retail trade. The subjects of this religious faith are excellent citizens and are always appealed to for assistance in public charities; they are more popular as municipal officers than pronounced protestant christians of any nationality. Leading commercial houses in all the republics have German branches operated by young men sent out from the mother country to conduct the American end of their business. It is quite the rule for these men to marry in the country, nor do they condescend to the inferior classes. Their positions are guarantees of character, so that they have access to the best families, differing in this from the English and Americans, who rarely marry with people of the Latin republics.

The blue eyes, fair hair, clear complexions and general bonhomie of the Germans make them singularly attractive companions to the merry, black-eyed brunette of our southern neighbors. By his wonderful adaptation to the national customs and popular convention, with his extraordinary ability in the mastery of language foreign to his native tongue, his absolute grammatical accuracy in construction with correct pronunciation, he becomes an accomplished member of society, a valuable citizen, a desirable neighbor and an agreeable companion; while the American, like the Englishman, always aggressive, often offensively so, rarely attains a command of the language superior to a "gringo" idiom and contemptuously mentions the people among whom he lives as "the natives," implying their slight remove in his conception from the aborigineés.

But the Englishman is better regarded than the average American, because he goes among the people as the contracted agent or clerk of a reputable commercial house, while the American is rarely other than

accident or an adventurer. In no case are either of these immigrants such representatives or instruments of an advanced civilization as their countrymen at home may properly imagine them. At their best, they are the simple agents of commercialism; and in Latin America, as at home, they leave their neighbors to that liberty in their pursuits, opinions, methods and manners which they claim and exercise for themselves.

To Brazil, as to Chile and to Argentina, have been presented lower classes of Germans, who have taken to agriculture and have grouped themselves in colonies, from which some of the more intelligent have escaped to the towns and cities, where they have entered the pursuits of the mechanic arts or trade.

The European economist, quoted by the American Bureau of Statistics, estimates that "German capitalists have invested $50,000,000 in Mexico and $225,000,000 in South America, of which $150,000,000 are in Brazil alone, in the southern provinces of which several great German colonization societies have long had powerful influence. Land may be bought there at half the price of government lands in the United States, and land that produces several crops a year in agreeable, healthy climates."

As shown by the figures, while only 51,000 Germans are settled among the states of the continent, outside of Brazil, the 1,000,000 in that country are colonized in five states.

In Paraná, with	80,000 inhabitants,	covering	6,000 square miles.
Santa Catarina, with	110,000 inhabitants,	covering	24,000 square miles.
Rio Grande do Sul, with	300,000 inhabitants,	covering	99,000 square miles.
São Paulo, with	540,000 inhabitants,	covering	121,000 square miles.
Minas Garaes, with	1,300,000 inhabitants,	covering	220,000 square miles.

These states with 2,330,000 inhabitants living over an area of 470,000 square miles contain 1,000,000 Germans, living among a people of whom only one sixth are whites of self-governing ability. Generally these immigrants are farmers, save, as already mentioned, laborers, who have been sent to the mining regions of Minas Garaes by the home colonization companies for work in the mines and the production of supplies for the mining operations.

It may also be noted that Central America is a favorite point for the German leaving home. But it should be said here that few, if not the more wealthy and cultivated among them, go to those states, where they are having a very important influence on commerce, the arts and every department of civilization. So important have these interests become that the German government has lately established there its first salaried consulate, where also are about a score of consular agents receiving their pay in fees. Their commercial interests, especially in Guatemala, have so developed that they have now in the five little republics $6,000,000 invested in real estate, industrial enterprises and

banking business. German farms and plantations cover more than 742,000 acres, on which are 20,000,000 coffee trees, while the trade between those states and Germany amounts to $12,000,000 a year. Throughout Central America, Germans occupy leading positions in business management, professional and social life.

II. *Condition of the Societies invaded by German Immigration*

We have passed the portals and come into the glory of a new century of this modern era. The genius of man, which has reared our present civilization through more than four centuries of patient culture, struggling to free himself from the divine right of priest and king forced upon his mind by superstitious fear of a tyrannical and mercenary ecclesiasticism, has at last invaded the highways of the heavens, followed the journeyings of other worlds and, driving away the guard, has seized the tables of their law, so long falsified by "sacred" authority, and brought them to earth for the common use of the race; has plunged into the heart of his own planet and, seeking the smelteries of the gods, brought forth their ores of light and power, illuminating the world and confounding the agents of "inspiration" by exposing the sources of creation.

By the omnipotence of carbon with the industry of the printing press, the world has been condensed and its nations drawn into the circle of neighborhood sympathies, with the elevating and degrading influences of the world's gossip; its gabble and wisdom, truth and falsehood, loving tenderness and brutal antagonism, so assorted, allotted and mingled, the nations are becoming one people. The political monarch is being forced to concede parliaments to thought, which dares deride royal pretensions, wherefore this century seems likely to witness the downfall of all enthroned power save that of the people. The last tyrant to fall, because the most difficult to reach, being ambushed in the superstitious apprehension of the masses, will be the religio-political governments of Latin America; governments that are not in any sense democratic republics, though so titled in their constitutions and proclaimed in their manifestoes. Comprehensively described, they are autocratic theocracies, in which the common people are under the dominion of the clergy, who, in their turn, are the instruments of the educated wealthy classes, holding control of the administration of the governments; or, when the laws are not to their purpose, organizing revolution to overturn their rivals of the party in power when they reckon themselves sufficiently strong in the reenforcing influence of the church.

There is, however, in every Latin state a party of which the grand objective is the religious and civil freedom to be obtained by the separation of church and state. This party recognizes the value of a public school system, like that of the United States, molding the pop-

ular mind to the habit and method of independent thought. In the parochial schools of the present, where the children have their first and, generally, their only training, the object appears to be the drilling into the young mind supreme reverence for the power of the clergy to inflict future punishment and bestow reward, with the church as an object of veneration in place of Deity.

The Roman pontiff is now without influence in appointing the archbishops, or superior clergy, in any Latin republic. The supreme political power of the state nominates the candidate because of his political relation to the party in power, and he is confirmed by the pope without question. By this method only can Rome maintain the slim hold it now possesses on a people, of whom the educated classes, clergy and laity alike, are agnostic when they are not absolutely atheistic. Their church is simply an institution of society, which confers a child's name with ceremonious dignity, marries him with the customary, established form and receives his dying breath in such compliance with ecclesiastical demand as shall secure for the corpse a burial in consecrated ground, which means a "respectable" interment.

So universally detestable is the popular reputation of the Latin American priest that in the more civilized cities of their realm they are not admitted to social life in the upper circles of society by self-respecting husbands and fathers of young wives and daughters. A result of this moral debasement in the font of ethical teaching is the general dull public conscience concerning all obligations, social, political and economic, that we actually find in existence throughout Latin America. It is seen in the smallest business transactions and the most important financial contracts. A South American bond without hypothecated security is a broad jest in all financial centers.

The aboriginal population of those regions are not civilized, but have been christianized through a system of oppression that has endured five centuries. Sarcastically entitled "citizens," they are without a voice in government, and when their tribal center is far removed from the larger cities, they are in a more repulsive condition of barbarism than when the cross was first raised over them.

When Pizarro subjugated the gentle subjects of the Incas, Perú had a population of 12,000,000 industrious, virtuous and contented souls, since reduced by Spanish slavery to less than 3,000,000; to-day, after a half century of recuperative government, raised to nearly 4,000,000, the systems of their christian conquerors having slain 9,000,000 in the mines by the meta, which kept one seventh of the population always at work for their masters, the Spaniards. Cannibals still roam in the territories about the head waters of the Amazon. In Mexico are districts where the women know no other dress than a piece of cotton dropping from the waist to the knee; and the Jesuits have controlled

them during all these centuries, superstitious devotees of the church, without a conception of modesty or chastity as recognized by our civilization. Reports of prefects of departments and governors of states annually present records of an unwholesome condition of public morality, often indicated by the exorbitant proportion of illegitimate births in a population generally amounting throughout Latin America to from 25 to 40 per cent. of the entire number in a republic.

At a meeting of the American Social Science Association, held in Washington in April, 1901, Ex-Secretary John W. Foster said of the Latin American republics: "The great mass of their populations are ignorant and uneducated; in many of the countries they do not even read and write the official language of their governments, and as a rule have no part in the elections." It has been claimed for the Spanish missionaries that they taught the Mexicans all over that country the Spanish language. Nothing can be farther from the truth. In a population of 14,000,000 not more than 4,000,000 speak the language of the government. When the railroad companies have had to employ laborers from the Sierras, they have been obliged to bring with each gang an interpreter who speaks the dialect of the tribe and Spanish, which the native does not understand.

These details are mentioned, not to prove, but to illustrate, a condition known beyond the necessity for proof by every intelligent citizen of the world. Every soldier from the Spanish islands learned the fact by personal contact; travelers from all over christendom who have visited those regions know the truth and entertain their friends with the recital. The thousands of Spanish prisoners to American arms in Cuba, transported to their homes, are become missionaries against the tyranny of their native church. All over Spain they have proceeded with violence against an institution that contact with the free thought of America has taught them to hate as the enemy of human rights; the auxiliary of tyrants "clad in the livery of heaven."

This corrupt ecclesiastical system, still striving to hold in subversion the consciences of 60,000,000 human souls in this western continent, is tottering in its power under the contempt of the educated classes, its tyrannical masters and the hatred of the common people, with the progressive intelligence of the popular conscience, to which the clergy is being continually forced to make unwilling concessions. It is also to be observed that contact with the Saxon world is stimulating the Latin factor of it to shake off the yoke of that ecclesiasticism which has debauched and, in every moral, intellectual and spiritual sense, degraded the masses to be the scum of the world's populations. At last, the head of the Latin church has aroused to the alarming fact of a great western awakening. Associated press despatches tell us that on June 28, 1903, the pope called the bishop of Ibague (Colombia) to an audience, in which he is reported to have conversed on conditions

prevailing in the South American republics and the "necessity of raising the standard of the clergy so that they may contribute to the better intellectual and moral condition and progress of the people of those countries." The clerical apprehension of approaching danger is shown in various attempts to hide or destroy ancient insignia of idolatrous superstition; thus, witness on the façade of the church of La Merced in Lima, the capital of Perú, there existed up to a few years ago the following inscription upon a fillet over the grand portal, "Indulgencia, plenaria, cuotidiana, perpetua por los vivos y los difuntos." It has now been removed under the sneers of an advancing civilization of the people and the sensitiveness of all to the comment of foreigners.

This is but a single instance among many illustrating the trend of a growing influence among the people, obliging the clergy to abandon its methods and pretensions. A half century ago, the priest in blessing the national troops in Costa Rica walked over the abased national flag to sprinkle it and the troops with holy water. To-day the flag is laid reverently upon a table and the priest walks around it in the performance of the ceremony.

Probably the story of the priest, Francisco Pablo De Vigil D.D., of Lima, is the most comprehensive illustration of the condition of life in its relation to the features here treated that can be presented in one single biography. This distinguished theologian, scholar and statesman was excommunicated from his church because he refused to accept the dogma of papal infallibility. Notwithstanding his expulsion, he continued to wear the ecclesiastical garb and the tonsure and to attend the functions of the church, occupying a seat among the laity. He had warm friends and sympathizers among the lower clergy, but could not receive absolution after confession, since he refused to renounce his error. The national government, recognizing his purity of character, his high degree of scholarship and devotion to liberty of thought, placed him in charge of the national museum, which is a great educational institution of Lima, and brought him into close intellectual contact with the students of the university, so that in this position he had the largest field he had ever yet possessed for influencing the growing mind of the nation. While occupying this station, he died. His death and funeral were as full of interest in the world of thought as his life had been. A personal friend in the priesthood attended him in the last hour and received his confession, but had been expressly forbidden to give him absolution, unless he renounced his error. His confessor relates that he was weeping as he knelt by the bedside of his dying friend, who laid his hand tenderly upon his head and said, "Don't weep for me, dear brother, but for the archbishop, whom you but obey; I am going before a greater judge than he." The body was refused admission to the church of La Merced for the ordinary requiem mass, and the clergy also refused the certificate required for burial in the

"Pantheon general," which, while "consecrated," is the property of the municipality. This body immediately, by municipal ordinance, authorized the interment of the body of Dr. Vigil within its consecrated grounds. When the body was brought from the house to be laid in the hearse awaiting its reception, a body of students stepped forward and took it upon their shoulders, bearing it reverently to the chapel of the cemetery.

But now, another surprise awaited the wondering public. As the funeral cortège moved along the streets of the city, processions of Free Masons in full regalia poured from the side streets and followed the train. On reaching the chapel, Masons took charge and conducted the burial service, in the name of human liberty; and in the chapel, which had been consecrated by the church, but was owned by the municipality. The same order conducted the ceremonies at the grave, with the solemn earnestness of men, who understood the act to be a declaration of independence against ecclesiastical tyranny. The higher clergy beheld the spectacle with fear and indignation, while the priests smiled solemnly to see their bishop defied in his own capital. None of them had dreamed that a masonic lodge existed in their midst; to-day the handsomest, best built and most modern structure in the commercial city of Callao is the Masonic temple.

Since then the city of Tacna, capital of a southern department of Perú, has erected a fine marble monument to the memory of Dr. Pablo Francisco De Vigil, who was a native son of that town.

This entire episode, in its defiance of the clergy, illustrates the longing for liberty in the better classes of Latin America. But, in all these republics, there is more actual liberty of conscience than is allowed by the written law, which, often angrily cited by the clergy, finds itself in such antagonism to the higher law of the popular conscience, that the courts of ultimate authority manage to fail of finding it in the statute books, written as it is under the unwritten decrees of an advancing civilization.

III. *German Influence in Latin America*

It is an interesting fact that in all the vigorous eloquence of the American press and politician, touching "German influence" in these continents, the real matter of German influence has not once been considered. European monarchism, interpreted by the Kaiser, has excited the patriotic bias of the republican citizen, as if the ambition of Cæsarism can ever establish its order among a people who have fought for and conquered their independence. German imperial power must not be confounded with German influence, which has been potent on this continent for more than a half century and will continue to be as long as Germany occupies her present transcendent position in the universe of thought.

It is not to be disputed that the German business man, whether in commerce or in the industrial professions, assumes always in Latin America a positive antagonism to the American from these states, often violent and offensive. This action is partly the exhibition of his inflated vanity and partly proceeds from his spirit of business rivalry.

Dr. Herman Meyer, a founder of a German colony in southern Brazil, in an address before the Berlin Colonial Society, said, in December, 1904, that United States merchants are trying to win the trade of the German settlers in Brazil and that therefore it will be necessary to assist the colonies with German capital for the purpose of building railroads and creating industrial establishments.

The pronounced opinion of Dr. Vosberg-Rekow, director of the Bureau of Commercial Treaties, before a meeting of Leipzig merchants, that "Germany must have annexation of more territory beyond the sea, with the organization and the direction of emigration thereto"; the warning of the Italian admiral, Count Canevare, that "European nations may have to consider the necessity of uniting against America," with the concurrent expression of Count Goluchowski, the Austrian minister of foreign affairs, are not agreeable trumpetings across the seas, but they bear no relation to the power or character of the German influence at present existing in these western continents.

A positive and powerful German influence, the grand ally of the Americanism of free opinion with its expression, is exercised in all countries settled by German immigration; it is radically liberal in religion and politics, without the element of anarchism; antimonarchistic and altogether contemptuous of conditions existing in the countries of its adoption.

This statement requires qualification when treating of the larger "assisted" colonies which contain inferior classes of population. Thus in Brazil a considerable proportion of the German immigration is of peasantry of Baden-Baden, whose people, the last to be joined in the German confederacy, came into the empire through conquest. The ruling power of the principality is protestant in religion, while two thirds of the population is Romanistic, and furnishes the element which is peopling the southern states of Brazil. They are, in the main, a thick-headed, patient, industrious race, repaying the Prussian contempt with sincerely cordial hatred. They find in Brazil a mentally stimulating life, an emancipation from protestant though liberal rule, allowing them an assumption of superiority over the natives of the new country. Their priests are men of character, superior to the native clergy in every element of intellectual, moral and spiritual life, while they possess a fair degree of learning and are devoted pastors. But these German peasants of Brazil are superstitious and illiterate when compared with the Germans, scattered over the continent as merchants, clerks, brokers, bankers, planters and teachers. Their influence on

the natives of the region where they live is but trifling, save in the particular of their superior morality, which is believed to be an elevating example, while, like all Germans, everywhere, they grow in their new soil towards liberal thought, being removed from the repressive influence of European old age. They are not in any sense subjects of German imperial power, but are the tenants of commercial companies. So that, while they are German colonists, they are not colonies of Germany.

If the material results thus far accomplished by the German government in its attempts at national colonization be the best that power is able to produce, it will appear an empty vanity to attempt further enterprises of the kind, save for the improvement of congested populations. In colonies of the empire, covering an area of 2,500,000 square miles there is a white population of 6,000 souls, of whom 4,000 are Germans, who in one year (1901) succeeded in producing a deficit of $7,000,000 above an income of $8,000,000. American Consul Harris at Eibenstock has said: "The ideal relation of a colony to the mother country is that which permits the colony to produce the raw material which the mother country will receive and return to the colony in a manufactured condition; but, in accordance with an irresistible law of economics, a colony with great material resources will gradually emancipate itself from the mother country. It is doubtful whether this will shortly be true of any of the present colonies of Germany. In almost every part of the world where her acquisitions are situated, there is in the same immediate neighorhood a colony of Great Britain or some other country better able to produce colonial products."

The only considerable collected German colonies, in other of the Latin American republics, are in Guatemala, Chile and Argentina. In Guatemala there is a German element of great respectability and influence amounting to real power, which promises more for an advancing civilization of the entire mass of population than is apparent in Chile or Argentina. But, in all three of these republics are German populations, not included in colonies, which must be considered with similar classes in every other Latin American state. These people are distributed all through those states, but are found more generally in the large towns and cities. They represent important material interests and are the potent "leaven which leaveneth the whole lump."

The influence of this portion on the communities in which they live differs curiously from that of the French, as is seen illustrated in the cities of Mexico and Panama, where the French have, during certain periods, been the controlling power in social life. The women of the upper classes of those cities, which have known French influence, no longer hesitate to appear on the streets clad in comely array, wearing bright colors in dress, with hats or bonnets in place of the sombre black suit of gown and mantilla. Thirty years ago, every woman in the

Panama cathedral was arrayed in black and even her head was covered with a black manta; there being no pews, she knelt on the stone floor throughout the service. Since the French began the work of the canal, the church has been supplied with pews and the women are wearing in the services the hats and bonnets of Parisian fashion with gowns and wraps à la mode.

German influence, on the contrary, so far as I have discovered, seems not to have affected the fashions of dress or social customs of the people, but is revolutionary to an extraordinary degree in its effect on the mental attitude towards the elements of civilization in politics and religion and the education of the youth. Many native fathers send their sons to Heidelberg, rather than to Freiburg, the school of their faith, though generally scientific students begin their studies at the technical institutions of the United States and finish them with two years at the Polytechnic School of Paris.

Notwithstanding the fact that German antagonism to mental and spiritual tyranny is awaking the popular sense to freedom, the molding of social conditions and the philosophic thought are distinctly French. The truth is the Latin spirit is French rather than German, so that Paris and not Berlin is shaping the social life of Latin America. The civilized world regards in wonder the spectacle of 60,000,000 people, who have thrown off the yoke of Spain, suffering in sullen silence the tyrannical imposition of an institution more strictly Spanish than any political monarchism they had ever known.

But the church in Latin America is to-day brought face to face with an army of organized thought, invulnerable to the senile bulls of ecclesiasticism. As Victor Emanuel was able in the interest of Italian unity to discuss the forbidden questions of the usurpation of civil power, in the privacy of the Masonic Lodge with his brother princes of Italy, so masonry is to-day, throughout Latin America, the safe and sacred cradle of liberty, an important instrument aiding to emancipate the state from priestly tyranny.

Masonry is making great strides in all the republics since the establishment of the new kingdom of Italy, which has been a lesson in method to the advocates of liberty of opinion, who have learned its value in freeing them from the espionage of those who mold and bind the shackles of thought. Its adherents are everywhere the advocates of the separation of church and state. Visible progress towards this desirable end is slow, but as sure as the irresistible march of time.

In this developing menace, the German has been the grandly potent factor throughout those regions. Everywhere he is the active leader in freedom of thought and in the conduct of masonic lodges. As it is not permitted to teach protestantism, a German, the grand master of the Peruvian orient, has established a newspaper in Lima, the capital city of Perú, which he calls the *Libre Pensador,* which is doing

effective work for freedom of conscience and secular education of the children; for which, in many of the republics, the city councils have established "municipal schools." The course of the *Libre Pensador* is supported by the higher classes of the community as a veritable watchman on the tower of free expression, and is doing much to relieve society of clerical scandals, which it trumpets with terrible denunciation and directness of personality.

The extraordinary material development of territories rescued from their Mexican slavery under clericalism and raised into the dignity of our American statehood, allowing them all their natural advantages for development, is an index of what the world may witness in the redemption of other Latin American republics. The advance in every higher condition of life in the Republic of Mexico, since her partial emancipation from this same wretched rule, affords a great encouragement to the moralist, philosopher and statesman, watching the progress of the world in the march of free popular thought, applied to the government of states.

The writer is an American, with three hundred years of unmixed American ancestry behind him, and he does not hesitate to declare his belief, after having lived nearly a score of years in Mexico, Central and South America, that if it should be the fortune of any considerable territory of South America to rise into the dominion of English, French or German civilization, it would denote a triumph of regenerating thought over a condition of slavery that should never have been permitted to establish a foothold in these continents. It would mean republican states that we could respect as neighbors, our equals and our coadjutors in advancing the conditions of liberty throughout the western world, instead of protegés, whose frequent acts of barbarism keep our country in constant apprehension of Monrovian interference that may embroil the nation in a war with the states of Europe. And for what? to sustain a people in maintaining republics? Nothing of the kind; but to save some miserable band of politicians from the punishment due their crimes against the illuminating ideas of this twentieth century, fruit of the highest civilization.

THE PROBLEM OF INTERNATIONAL SPEECH

By ANNA MONSCH ROBERTS
MANHATTAN, KANS.

TO any thoughtful student of affairs, it is perfectly clear that, as the years go by, all the nations of the earth must inevitably become more and more closely linked together in all their interests. The present highly perfected modes of communication will become greatly improved and vastly extended. All the economic and material commercial, as well as all the intellectual interests of each people will become of increasing significance to every other one. National boundaries will, in the lapse of time, become of as purely formal, merely administrative importance as are our American state and county boundaries to-day. Already in The Hague tribunal we have the beginnings of an international supreme court. In time the United States of Europe is a conceivable possibility, with abolished frontiers and armies reduced to police forces. Commerce and industry are certain to end the folly and barbarism of war; since the rise to self-consciousness of the working classes (who fill the armies) will make their community of interest the world over plain to themselves, and they will see that to hire themselves out to kill one another is a crime to common humanity.

One prime obstacle to that clear and perfect understanding among human minds everywhere over the broad earth lies in their inability fully to comprehend one another's thoughts and purposes, because of the diversity of tongues. That this is a very serious obstacle to human progress and the development of the globe, becomes increasingly evident the more readily and easily possible communication by mail, telegraph and actual travel becomes. So long as the different peoples read little, wrote less, and traveled scarcely at all, the polyglot condition of the world was a matter of little interest. To-day it has risen to be a most serious hindrance and inconvenience to the steps of advancing humanity. It is true that almost all educated persons feel impelled to-day to attempt the learning of other languages than their own, if only to come in touch with the civilized world's literature, aside from the ordinary practical considerations. Sometimes this feeling petrifies into the pious attitude ironically commended by Lord Palmerston, who said that while it was not necessary that every gentleman should *know* Latin, he should at least have *forgotten* it.

It is trite and easy to say that this is a scientific age, but one must actually have worked in some field of science to realize the blunder-

ing, clumsy stupidity of the present language situation. A good half dozen languages at least, must become the working tools of him who conducts scientific research of any importance; for men all over the civilized globe are carrying on investigations in all the departments of science, and their results are being published in hundreds of scientific journals in many tongues. To be sure, reviewers having special acquaintance with the less known languages translate many of these investigations—or, at least, more or less imperfectly report their main features in the journals of science published in German, French, Italian and English, which all scientific men are supposed to read. It goes without saying, however, that hundreds of valuable papers are buried each year in the minor languages and dialects, while even in the four great European tongues much of importance is overlooked by reviewers in the others. The situation is even worse when an international congress is convened. Such meetings are being held with increasing frequency—twenty-two in Geneva, Switzerland, last summer—to consider all topics of common human interest: Medicine, prison reform, agriculture, peace, the Red Cross, sanitation, education, besides the special societies for all the great branches of science. At present it is the universal rule that at all such gatherings papers may be read and discussions conducted in any one of the four languages above mentioned. There are always some, often many, who can understand formal papers, if read very slowly, fairly well in at least two of these idioms. But to converse freely, easily and continuously with others upon all topics of common interest in another than one's own native tongue is a feat more often imagined than realized.

In view of the amazing progress we are daily achieving in all the other departments of human life, why, with respect to the one indispensable tool of language, should the human race suffer no improvement? Why not agree upon one auxiliary common language, which all people of moderate education may easily learn. Why must the Magyar or the Slav, the Chinese or the Japanese, of culture and intelligence, be barred by language from the tremendous world of thought in the intellectual life-centers of the globe? In the to-morrow that is coming, shall we exclude ourselves from Russian, Chinese or Japanese life and thought, as much as they to-day are excluded from ours, except at the expense of laborious language-learning. But consider for a moment the situation confronting, let us say, a cultivated Japanese desirous of entering European thought. First, Greek and Latin ought to be acquired, and English, French and German absolutely *must* be mastered, every one of them absolutely alien to his own tongue in grammar and vocabulary, and even in the very written signs themselves.

It is one thing to engage in the study of foreign languages with

love in one's heart for the beauty of their literatures; it is quite another, and a different thing, to endure years of joyless toil, acquiring a smattering of many tongues in order to gain a mere technical ability to read the facts of science internationally. What wanton brain-waste is here. Scientific investigation and discovery are of no nation, of no language, but to be in possession of the knowledge of them, in the present crude stage of our social development, we must learn a half-score of the national languages in a way that is subversive to all mental discipline, to all culture. Either we are skated over the thin ice of a "conversational course," getting our vocabulary with our breath between glides, and with grammar served daintily, like Nabisco wafers at a luncheon. Or we have had, let us say, the good average representative "language course" in school and college. We have "pried over" from one language into another endless imbecile sentences, involving the fact that Marie, when she shall have had a lead pencil will have been happy; that Henry's uncle, who is about to return from Frankfurt, desires an inkstand for his little sister; or concerning the ravages committed by the red cow of the good grandmother in the green garden of the rich count. We have read a half dozen plays; have rendered slowly, dully, baldly, into "translation English," a few hundred pages, more or less, of standard prose and verse—and we have "had" French, we have "had" German. How many of us must testify to the inadequacy of the average "required" courses in language to give appreciation for foreign literatures, while of course their utter inefficiency, so far as the direct conversational use of these tongues is concerned, must be self-evident, in view of the laughter-provoking absurdities in style and diction, the impossible pronunciations and accents we achieve.

In one of George du Maurier's books, two little English boys in a French school are requested by the master, proud of his own English, to render into its English equivalent, "je voudrais pouvoir." Translated "I should like to be able" by the little Englishmen, they were at once corrected by the master. "Non, non, you do not know your native tongue. It is to say, '*I vould vill to can*'" Being then told to translate, "*je pourrais vouloir*," from the small bad boys came the alert response, "*I vould can to vill.*"

We all know, from both literature and life, the appalling waste, the tremendous throwing about of brains to little use, in much of the current study of foreign languages.

Recognizing the difficulties involved in learning the natural tongues, the minds of men have been occupied for more than two hundred years with projects for an artificial language that should be the means for international communication. But the thought naturally suggests itself—why should we not make use for this purpose, of some one of the already existing idioms, developing and simplifying

it if necessary. Logically the great classical tongues of Greek and Latin come in first for consideration. It has been demonstrated, however, that for many reasons they are impossible. Their highly inflected structure, their inverted sentence order, especially in the case of the Latin, are wholly alien to the modern mind. For centuries, indeed, Latin retained a certain sort of internationality among scholars and churchmen, but not in the common walks of life; while Greek, in spite of the four millions of modern Greeks, could make no propaganda, because, in addition to countless inflections, it retains an unfamiliar alphabet.

Considering the four principal modern languages, French, English, German and Italian, the first two alone have ever been able to entertain even a hope of becoming international. Among diplomats, courtiers, officials and people of polish and culture generally, French has of course for many centuries been regarded as an indispensable tongue, and in this way it has actually attained to a limited amount of internationality. The precision, neatness and certain high quality of style in its phrase, its rather simple grammar and its capacity for expressing nice distinctions and fine shades of meaning, must always strongly appeal in its favor. Its difficulties of idiom, and particularly its pronunciation and accent, which absolutely can not be correctly acquired by adults, and which can be conveyed only by the cultivated French teachers themselves to ourselves as children, preclude all hope for the universality of French in any but an academic sense.

Germany, the Mecca of scientists, publishes every year an absolutely appalling mass of scientific literature; so that to every investigator, a reading knowledge at least, of German, is as indispensable as his native tongue, whatever that may happen to be. Yet German, cumbered with a clumsy, inverted sentence-order, with its complex inflections of nouns and verbs, its incredible genders and its rather difficult pronunciation, has never dared even to aspire to internationality. Except that the Germans are indefatigable workers, and publish an inconceivable volume of scientific literature, their tongue would to-day be no more widely known than Danish.

As to our own well-beloved mother tongue, we are told on every hand (in English-speaking countries) that English is rapidly becoming the world-language. We are confronted with census statistics to this point; but an analysis of the figures somewhat weakens the force of the general assertion. In America, and in the English and American dependencies, there are absolute hordes of non-English-speaking peoples. But even were this otherwise, allowing the utmost to the figures, we should still have but a minor part of the inhabitants of the civilized world as users of English.

What are then the inducements to bring the rest of the world to the speaking of English? Who does not remember the story of the valiant

British matron, who, on being accosted in southern France by the phrase, "You foreigners," replied: "No, *you* are '*foreigners*,' *we* are *English*." To your true, insular, middle-class Englishman, all the rest of the world, with patronizing exception of the Americans, is composed of "foreigners," speaking various absurd jargons, wholly impossible to understand, but really quite unimportant after all.

Your American, knowing in his bones that he is a hopeless hash of Irish, German, Scandinavian and Hebrew, with garnishings, perhaps, of "Anglo-Saxon,"—whatever that may be or ever was—is yet no whit less provincial in his noisy assertion of the manifest destiny of the language which he has learned to speak in a way, and with various brogues and accents. To the language slogan of the English, he joins perforce the American Declaration of Independence and the Constitution, both of which are to "follow the flag"—at more or less discreet distance in their more than Roman triumphal progress over the lands of the hitherto unappropriated peoples waiting to be discovered and utilized. If there be such a thing as an Anglo-Saxon idea, upon which England and America are in perfect spiritual accord, it is that all the rest of the unexploited races of the globe should be put at once into Derby hats and trousers, made by the Israelites of London, New York and Chicago, to buy which, satisfactorily and abundantly, the prospective purchasers must, of course, be made to learn "the language of Shakespeare."

The American, who is also an idealist and under illusions, would graft on the suffrage. "Buy our goods, wear our clothes, talk English and vote—for us," is the good orthodox, Anglo-American receipt for civilization.

Suppose, however, we drop national prejudices for awhile, and look at our language through other eyes.

Modern English is, as we know, a magnificent composite, possessing the richest, most varied, most expressive vocabulary imaginable. As fully heir of the polished classical tongues through the Norman French as of the homely and rugged Teutonic stocks through the Saxon, our English language certainly offers us a wealth of words without compare among the civilized tongues of to-day. Add to this a minimum of grammar, an absolute simplicity, flexibility and mobility of structure, and why should English be other than the best possible international form of speech?

What then are the deterrent factors which operate to hinder and check the spread of English? First and foremost, our absurd, impossible and chaotic spelling. To language students, of course, the evolution of our orthography is clearly traceable; but to the plain man of other nations, who has not grown up in English from King Alfred, nothing seems more witless, more grotesque, lawless and incomprehensible than our spelling, and its utter divorce from pronunciation.

We spell *s-l-o-u-g-h,* and call it "sluff" if we refer to an abscess, but "sloo" if we refer to a swamp, over which the wind may be said to *s-o-u-g-h*—"soff." Remove but the initial "s," and we no longer have a swamp, but a lake—*l-o-u-g-h,* pronounced "loch." Change but the "o" to "a," and we have *l-a-u-g-h*—"laff," but *c—a-u-g-h-t*—"cawt," or *dr—a-u-g-h-t*—"draft." Or, again we have *t-o-u-g-h*—"tuff," *b-o-u-g-h*—"bow," *t-h-r-o-u-g-h*—"throo" (but th-*o*-r—o-u-g-h, "thurrow"), *c-o-u-g-h,* "cawff," *d-o-u-g-h,* "doe," and *p-l-o-u-g-h,* "plow."

"*Coughing* in the chill wind *soughing through tough boughs,* which overhang the *sloughy dough*-like *slough* that joins the dismal *lough,* the lonely peasant sat beside his *plough,*" would make good verbal gymnastics for the ambitious foreigner.

The sound of "e-i" is one thing in *freight* and *weight,* and another in *sleight* and *height*; and in "either" it is either *eyther* or *eether,* while to the Irishman it is *nayther.*

B-o-w is the "bō" to shoot with, or the "bŏw" of a boat. A man may *glōw* with pride, or *glŏwer* in wrath. We "mōw" the hay, but put it into the "mŏw." We all agree to say "mōon" on the one hand, and "bŏok" on the other (except in England where they say "bōok"), but some of us say "rōot," "rōof" and "hōof," while others say "rŏot," "rŏof" and "hŏof." We all of us put a "fŏot" into a "bōot"" just as surely as we put a "toe" into a "shoe."

Is it any wonder that our English word system seems to a foreigner a museum of unlabeled curiosities?

Our pronunciation and accent, peculiar in themselves, varying, moreover, to distraction over the English-speaking world, are just as serious stumbling-blocks to others, as, say, French and German accent and pronunciation are to us. The six sounds of "a," the four sounds of "e," the two of "i," the five of "o" and the four of "u" give us those delicate assonances, and that fine shading of sound in words that makes for variety, interest and charm; but the complexity with which those twenty-one unmarked vowels invest the correct pronunciation of our English language is absolutely maddening to foreigners, especially since no one can possibly predict from the pronunciation of the vowels in one word their pronunciation in any other word having essentially the same spelling, and no one can possibly say what extraordinarily diverse combinations of vowels and consonants in English may not be pronounced exactly alike.

The very names, moreover, that we give to our vowels, and which are their principal and most frequently recurring sounds in our words, are, with the exception of "o," peculiar to English alone among the European family of languages, as applied to the letters in question. The so-called "continental" sounds of a, e, i, o, u, as in singing do, re, mi, fa, are practically universal, except in the English-speaking

countries. Indeed, there seems to be, at least with us in America, a wide-spread sort of shamefacedness about the use of any other but the flat "ā" and "ă" sounds for "a," and the long "e" and "i" sounds for those letters. "Ask," "half," "waft" are pronounced far and wide as "ăsk," "hălf" and "wăft," if not indeed "āysk," "hāyff" and "wāyft." "Amen" is "aye-men," "Alabama," "Kansas," "Iowa" are attractive in their vowels, properly pronounced; but "Ail-bay-ma," "Kain-zuss," "Eyé-o-way" or "Eye-ó-wi" are sufficiently common to indicate the trend among the unchecked multitudes. The Spanish "Colo-rä'-do" is beautiful; but what of our universal "Colo-răd'do," to say nothing of the unspeakable, but, alas, not unheard, "Colo-rāy'-do"? Americans, especially western Americans, do seem to feel it an affectation to use correctly the available sound-materials of the English tongue.

The point is, that while our vowel sounds do admit of beauty and euphony in the spoken tongue, and while our better speakers and more cultivated people do actually use their delicate shadings, to the delight of sensitive ears, the general drift among the English-speaking masses is to limit themselves to the use of a few of the least attractive and melodious of these sounds, and to those which are the least familiar to the masses of other nations as applied to the letters in question. This tendency certainly does not add to the allurements of English for foreigners. So far as the consonants are concerned, we undoubtedly possess one combination, the "th" sound, as in "the," which seems to present unusual difficulties to almost all other peoples. Who can formulate a rule that will cover the irregularities exhibited by "gem" and "get," by "ginger" and "gimlet," by "gill," the measure, and "gill," of fish; of "s" in "serve" and "preserve," "sound" and "resound," "hawsers" and "trousers," that will serve to aid the foreigner learning English?

Taking our orthography as a whole, there seems to be but little hope for the success of any radical scheme for revision. Witness the hoots of derision that, from London to San Francisco, have followed at the heels of Mr. Carnegie and his simple spellers, with their little handful of three hundred phoneticized words. As a matter of fact we are proud of our spelling as a national heritage. It preserves for us "the history of the language." We have a word "phthisical" which we should spell "tizical," since that is its peculiar pronunciation. We refuse to spell it in that way, because the combinations "ph" and "th" have been arbitrarily chosen to represent two Greek letters that do not exist in our alphabet! Despite the weakness of the argument for our orthography as preserving the historical origins of words, it remains as the most potent, because the most sentimental obstacle to reform, unless it be that blind subservience to routine, that love of the unchanged thing for its own sake alone. Be this as

it may, our English orthography will gradually, and in time, conform more and more to phonetic principles. But for the practical needs of the non-English, the interest of the language as a world speech, the movement is fairly glacial in its slowness, and the world will not wait.

Our English grammar, while simple in the main, presents some most eccentric irregularities in the conjugation of the verbs and the nouns. Consider some of our amusing singulars and plurals. A dealer, wishing to buy a dozen of that tailor's article called a "goose," after hanging despairingly between "geese" and "gooses" wrote "Send me one tailor's goose. P. S. Send eleven more of the same." We say "mouse" and "mice," but "house" and "houses" (howzes), "blouse" and "blouses" (blowses), while we also say "grouse" and "grouse" alike in singular and plural.

Perhaps our verbs are simple in their use for the most part; but how many of us are absolutely safe on our feet with respect to the use of "may" and "can," of "flee" and "fly," of "shall" and "will," or, dare I say, even of "sit" and "set," or of "lie" and "lay" on occasion? We think we know we *sit* down, that the sun and the hen, *set,* and that we *set* bread. And perhaps we are quite positive as to what we and the sun have done, grammatically speaking, when we have concluded our actions. But after the setting hen has commenced to "set," has she "set," has she "sat," or has she been "seated?" We are as confident that sun "rises" as that it "sets"; and as confident that we "raise" as that we "set" the bread, but how many of us do not vaguely wonder at times, when the process is over, whether that bread has really "risen," or whether it has not "raised" after all?

The conjugation of the verb, that bugbear in all languages, has been reduced to a trifle in English, but we must not forget the distracting irregularities in the past and perfect tenses which our children and uneducated people with logical instinct are constantly endeavoring to straighten out. Why need we say "catch" and "caught," but "snatch" and "snatched," "sing, sang, sung" but "bring, brought, brought"? We say "see, saw, seen," "saw, sawed, sawn." But put the two together into "see-saw," and behold, we say that we have "see-sawed," not that we have "seen-sawn." We have "lit," or we have "lighted" the lamp, but we have "bitten" the apple, even against the authority of the baby, who says "bited." There are those of us who would find it immensely easier to tell whether a man *had been* "drunk," than to know at once, and on the spot, whether the cause of his intoxication were something he "had drunk" or "had drank."

To conclude: the presence of numberless colloquial idioms, impossible to "parse" or to explain by any simple rule, such as render the plays of Shakespeare almost incomprehensible to foreigners, such as throw into despair the students of Aristophanes, these are the

characteristic features of every "natural" language, different in each, and no less difficult in the English than elsewhere. While they give a tongue much of its piquancy, its individuality, they immensely augment the difficulties of its mastery.

But, finally, there are two fundamental inescapable facts, inherent in the nature of things, which will inevitably make it impossible for any great living tongue—the native language of any people, however powerful and aggressive—to become, in the widest and most real sense of the word, international. First, the essential fact that no single such language, however broad, even the English, contains in its structure, vocabulary and idiom, enough of the elements of internationality already present and available to make it acceptable to, and easy of acquisition by, all other peoples. In all cases, the use of any single existing language internationally, involves the neglect of valuable, useful, beautiful, skilful forms of speech, possible in each of the others. The second, and perhaps the most serious fundamental obstacle exists in the mutual jealousy of nations, and national, provincial pride in one's own language. The experiences of Russia with Poland and Finland, of Austria with Hungary and Bohemia, of Germany with Alsace, are instructive.

To-day the nationalistic tendency is rampant in every tiny state and dependency in Europe; is fermenting among all the black and brown and yellow peoples over the earth who have heard of Japan's victory over a white race. And as the natural concomitant of this tendency, or indeed often as its main expression, we see dozens of petty dialects, once thought doomed to be swallowed up in a few of the great languages, now not only resisting furiously any such engulfment, but aspiring themselves to be great, to be spoken widely over the earth. Instead of Europe, for example, becoming more homogeneous in language with the development of the great consolidated states, it is apparently becoming more heterogeneous. The Bulgarians would Bulgarize the Balkans, including Macedonia, which the Greeks in turn are equally determined to Hellenize. Roumania and Servia have developed a national pride of language undreamed of in the seventies. Neither Russia nor Germany, despite the harshest measures, has succeeded in displacing Polish in its share of the dismembered kingdom. Every patriotic writer in Finland, in Lithuania, in Bohemia, rejects the great "world languages" for Finnish, for Lett, for Czech. Even the Irish are fervently reviving Erse. The Hollanders show no signs of a readiness to abandon Dutch for German, nor do the Walloons of Belgium intend to yield to the dominant French of their state.

As once in the early middle ages, writers in Italy and France, in England and Germany, disdained to express themselves in the com-

mon vulgar speech, owning Latin alone as worthy of putting on parchment. As later, Charles V. of German-Austria, told of how he talked in Latin to God, in Spanish to his family, in French to his courtiers, in Italian to the ladies, and—in German—to his horses only. So, not longer ago than in the last century, ambitious writers in the minor tongues, disdainful of the "peasant dialects" smacking of the soil, set their thoughts over into French, spoke in French, thought in French. To-day there is scarcely a tongue in Europe, however obscure or forgotten, that is not sedulously cultivating its own idiom in a conscious literary way.

On the edge of our world are Arabic, Chinese, Japanese, Persian, spoken by vigorous, populous national stocks, emerging into or fully participating in our complex international life, coming closer and closer every day by rail, steamer, telegraph and wireless, and to-morrow by the airships. Under the wise control of England, the native polyglot hordes of India are developing, preparing for a future nationality, which will not be English; in which the English language will remain what it is to-day, a foreign tongue. Over the huge domains of Mexico, Central and South America, millions upon millions of swarming people in the days to come will fill these lands with a vast Spanish and Portuguese speaking population. Will these then be among the "minor languages," to which their present position in Europe now relegates them?

What, then, of all these strong peoples who refuse to be assimilated, who are engaged in amplifying their own languages, and have no intention of meekly becoming absorbed by ours; who buy and sell, farm, mine and manufacture, produce and exchange increasingly, who share in the world's power of thought and expression, who are making or will make great discoveries in science, who will meet in conventional dress with our august selves, whether we like it or not, around the council tables of the globe?

Tell me, is any single national form of idiom adequate for all of these? Will any such be accepted by all of them? Will the whole world of human races, with its hundreds of languages and dialects, blunder along forever, chained in the shackles of polyglot speech?

Is a world language, then, really possible? As a universal language, in the sense of one that is to replace all others,—manifestly not, or if at all, only in some extremely remote epoch. How, then, shall we achieve the more immediate, rational and practical aim, of acquiring a single *auxiliary* medium of international speech, that shall replace no single language, however obscure, that shall remain forever neutral, and that shall be equally acceptable to all? Clearly, not by means of any existing national, "natural" tongue, but through the outright construction of an "artificial" language, which shall possess:

First, a vocabulary having a maximum of internationality in its

root-words for at least the Indo-European races, living within or bordering on the confines of the old Roman Empire, whose vocabularies are already saturated with Greek and Latin roots, absorbed during the long centuries of contact with Greek and Roman civilization. As the center of gravity of the world's civilization now stands, this seems the most rational beginning. Such a language shall then have:

Second, a grammatical structure stripped of all the irregularities found in every existing tongue, and that shall be simpler than any of them. It shall have:

Third, a single, unalterable sound for each letter, no silent letters, no difficult, complex, shaded sounds, but simple primary sounds, capable of being combined into harmonious words, which latter shall have but a single stress accent that never shifts.

Fourth, mobility of structure, aptness for the expression of complex ideas, but in ways that are grammatically simple, and by means of words that can easily be analyzed without a dictionary.

Fifth, it must be capable of being, not merely a literary language, but a spoken tongue, having a pronunciation that can be perfectly mastered by adults through the use of manuals, and in the absence of oral teachers.

Finally, and as a necessary corollary and complement to all of the above, this international auxiliary language must, to be of general utility, be exceedingly easy of acquisition by persons of but moderate education, and hitherto conversant with no language but their own—in all a most formidable and exacting list of requirements. Is it possible, is it worth while to attempt to fulfill them?

The redoubtable Doctor Johnson, on visiting the Giants' Causeway in Ireland, remarked that "it was worth seeing, but not worth going to see." By a sort of analogy, there are very many people who would doubtless endorse the idea of an international tongue, were one achieved and at hand, but who would not, in the absence of one, consider the difficult game of its devising worth the candle of its getting. However, it is interesting to note that this very fascinating problem has occupied the minds of men to such an extent during the past two hundred years that no less than sixty distinct systems of international speech have been published within that period. That these attempts are not to be classified with the chimeras of perpetual motion and the like, we may assure ourselves from no less authoritative an opinion than that of the late Professor Max Müller, who gave it as his deliberate judgment that an artificial international language, was not only a necessary, but a practical and feasible project. That it is inconceivably difficult so to combine all the necessary features of such a language as to ensure its general adoption is evidenced by the fact that out of the sixty systems referred to, but two have actually

succeeded in becoming more than printed theories. But two have ever been spoken and written by any number of people.

The first of these was Volapük, of which the author was Johann Martin Schleyer, born in Baden, Germany; a Roman Catholic curé, of a village near Constance, in Switzerland, where he published in 1880, a "Grammatik der Universalsprache für alle Erdbewohner." A few years ago he was still alive in Constance, having survived his language. His admirers credited him with a knowledge of eighty-three tongues. Volapük found an active propagator in Dr. August Kerchhoffs, professor of modern languages in L'école des hautes études commerciales of Paris. Beginning about 1886, it spread rapidly through France, and thence to the great cities of Europe and America. In 1889 there were 283 Volapükist societies scattered over the globe; its adherents were estimated at about a million; the number of published books on Volapük amounted to 316, of which 182 appeared in 1888 alone, and which were written in twenty-five languages. There were some twenty-five journals devoted to its propaganda, of which seven were published in Volapük alone. Three international congresses were held, the last one in 1889, in which the proceedings were in Volapük, and the language seemed to have become an established fact. But the same year saw the beginning of its decline, which was far more rapid than its rise. To-day Volapük is among the dead languages, possessing but a handful of faithful adherents.

The rapid rise and spread of Volapük, from 1886 to 1890, and its subsequent decline and ultimate extinction, demonstrate that the desire for an international language was universal, and that Volapük, in part, fulfilled the requirements. A study of that language clearly reveals the causes of its success, as well as of its failure. The grammar was simple and regular in construction, except in the multiplicity of its verb inflections. The letters had each but one sound; the words were absolutely phonetic; but the language had two fatal defects, the complexities just referred to in the conjugation of the verb, and the fact that the words were not formed on already existing international roots. Most of the root-words used were to be found in the Teutonic languages alone. All of them were mutilated beyond recognition; sometimes according to some phonetic rule, oftentimes according to a wooden arbitrary outline. Many of the words were actually "made up" meaningless sounds constructed according to a mechanical scheme of the author's. At best, Volapük looked unfamiliar, was inharmonious, ugly and uncouth in appearance and sound, and failed in the primary needs of an international tongue, except in the fact of possessing a grammar far more simple than any of the "natural" languages. As a matter of curious interest, and to illustrate some of the salient characteristics of the language, the Paternoster is given in Volapük, as follows:

"O Fat obas, kel binol in süls, paisaludomöz nem ola! Kömomöd monargän ola! Jenomöz vil olik, äs in sül, i su tal! Bodi obsik vädeliki givelös obes adelo! E pardolös obes debis obsik, äs id obs aipardobs debeles obas. E no obis nindukolös in tentadi; sod aidalivolös obis de bad. Jenosöd."

Note: Simple vowels with continental pronunciation; Umlauts as in German; consonants as in English, except c (tch), g (always hard), h (German ch), j (French ch), x (always ks), y (as in yoke), z (ts); tonic accent always on the last syllable of the word.

The second successful attempt at devising an international form of speech found issue in Esperanto, now apparently past the experimental working stage, and seemingly launched upon a rising tide of popularity and success. Some 100,000 people are now said to be able to correspond in Esperanto, and a large number of these speak it fluently. The number of the Esperanto groups seems to be increasing by leaps and bounds, and is placed at about three hundred thus far, distributed over all the four quarters of the globe. The propaganda has even reached Japan, which has fifteen hundred Esperantists, and a journal published in Japanese and Esperanto, and the very latest move appears to be the proposed invasion of China. In all about twenty journals are devoted to Esperanto, the organs of affiliated societies in each of the chief European states and in America. Seven magazines are published exclusively in the language, including some quite pretentious literary, illustrated and scientific monthlies. The London Chamber of Commerce has adopted Esperanto as a commercial tongue, and has organized classes and examinations in the language. Commercial schools in England, France, Germany and Sweden are offering courses, and in America, voluntary classes have been instituted in a number of our high schools and universities. In France, the language has received the approbation of the minister of war and marine, who commends it to the French military service. Finally, Esperanto has received the unqualified and enthusiastic endorsement and support of men eminent in language studies, the sciences and the arts, in every important country. Among these may be cited the late Professor Max Müller, of Oxford, and among living Englishmen, Professor W. W. Skeat and Sir William Ramsay; in Germany, the great name of Ostwald stands first, while in France the language seems to be enjoying among the intellectual élite a veritable *réclame*. Academicians, university professors, professional men, are flocking in imposing numbers to the ranks of the wearers of *la verda stelo*. Berthelot, Poincaré, Boirac, rector of the University of Dijon; General Sébert of the French army, indicate the personnel of the Esperanto movement in France, while in far Russia, rears the titanic figure of Count Leo Tolstoi, friend of humanity, as the champion of Esperanto in the name of universal peace and good-will among mankind.

There has already been inaugurated a system of Esperanto consulates throughout the world, with resident consuls, charged with the interests of Esperanto travelers. A "Centra Oficejo" (Central Office) has been established in Paris: an "Adresaro," or published list of the names and addresses of the adherents of Esperanto throughout the world, is issued annually, and a very considerable volume of literature, original and translated, already exists in Esperanto. Finally, two eminently successful congresses have been held: the first in Boulogne-sur-mer in France in 1905, and the second in Geneva, Switzerland, last August. At both of these congresses, hundreds of delegates from twenty-five or more nationalities met, conversed, transacted business in general. Numerous section meetings were held on various topics. Public programs were presented—theatrical, musical and literary—all in Esperanto. The new *American Esperanto Journal,* in its initial number of January, 1907, publishes an interesting letter from Dr. E. Y. Huntington, assistant professor of mathematics at Harvard, describing his experiences at the Geneva congress, from which extracts are as follows:

> When I arrived at the congress I had only a reading knowledge of the language; that is to say I had read some five or six hundred pages of Esperanto literature, but had never had an opportunity for speaking the language, or for hearing it spoken. Imagine my surprise and delight at finding that I could understand everything that went on from the very first day, and that within a few days I was able to use the language myself sufficiently well to spend a very profitable day conversing with a French philosopher, with whom I could have had no oral exchange of ideas without the aid of the new language. . . . Esperanto was for us both an indispensable means of communication. . . . The congress itself was a continual source of amazement to those of us who had been rather skeptical about the possibilities of an artificial language. The answer to all objections simply is—*the language works.* . . . The language was used at the congress for all the purposes to which a language can be put: general conversation, lively busy meetings, with spirited and eloquent extemporaneous debate, elaborate theatrical programs and church services. Any stranger dropping in at one of these Esperanto gatherings would certainly have supposed that he was in a foreign land where the people were talking in their own tongue. The experimental days are over; *the language works.*

The third congress, which will be convened in Cambridge, England, this month, is already arousing unusual interest.[1] The authorities of the University of Cambridge have proffered the use of the university buildings for the sessions of the congress, and the municipal council of the city of Cambridge has tendered the use of the city hall and other municipal buildings for administrative functions. In our own country, the growth of the Esperanto movement is surprising. All of the large cities have become centers of enthusiastic and rapidly growing groups.[2]

[1] This article was prepared in January, 1907.

[2] During the writing of these lines, one of our most eminent journals, *The North American Review,* has allied itself definitely with the Esperanto propaganda, lending the inestimable prestige of its great influence to the interests of the language in America.

Finally, just what *is* Esperanto? Esperanto is the name given to a language composed by Dr. Ludovic Lazare Zamenhof, a physician of Warsaw in Russian Poland, born in 1859, in Bielostok in Russia, and now, therefore, in the prime of life. His first publication, issued in Warsaw in 1887 under the pseudonym of "Dro. Esperanto," literally translated, "one who hopes," bore the title "Langue internationale, Préface et manuel complet." The project, which had occupied the author from his youth, made scarcely any impression in the first years after its publication. Volapük then held the field, after the utter fiasco of which, Esperanto suffered from the effects of the general wave of skepticism, ridicule and obloquy that followed in the wake of its failure. It was indeed a considerable time before a new proposal for an international language could so much as gain a hearing in Europe. But Esperanto found a brilliant expositor, also in France, in the person of M. Louis de Beaufront of Louviers, to whose enthusiastic adhesion to the language in its early days is undoubtedly due to a very considerable degree its present success. To an almost fanatical enthusiasm M. de Beaufront conjoined extraordinary talent and ingenuity in the exposition of the merits and claims of Esperanto, and marked tact and cleverness in disarming its opponents. After ten years the effects of the efforts of the founder and his supporters began to be felt; and France soon began to teem with the Esperanto movement. To-day, what began as the desperate struggle of a forlorn little band of idealists, against contempt, ridicule and misrepresentation, and against almost hopeless odds, has risen to the proportions of a formidable affair of international significance, challenging the attention of rulers.

What now are definitely the claims of this remarkable tongue, the sole achievement of a single human being, wrought unaided by a single brain, a work of supreme genius? Without going into one slightest detail, let it be simply said that it answers fully to all the fundamental requirements above mentioned for an international language. Its grammar can be read and perfectly understood in an hour. The pronunciation is simplicity itself, as the letters have each but one simple sound, and the accent rests always on the same syllable, the penult. Seventy per cent. of the word-roots will be recognized at sight by a person of good education in English alone. The utter simplicity of its syntax might make it appear as though such a language must necessarily be bare, meager and inexpressive. On the contrary, as the result of its extraordinary structure, it is ample, rich and full, with much of the flexibility and mobility of English, much of the style and precision of French, not a little of the elegance and grace of Italian, while in great measure it has the full, sonorous quality of sound and imposing dignity of form peculiar to the Latin.

By way of illustration, compare the Paternoster in Esperanto and Latin.

Patro nia kiu estas en la ĉielo,
sankta estu via nomo;
venu regeco via;
estu volo via, kiel en la ĉielo,
tiel ankaŭ sur la tero.
Panon nian ĉiutagan donu al ni hodiau;
kaj pardonu al ni ŝuldojn niajn,
kiel ni ankaŭ pardonas al niaj ŝuldantoi;
kaj ne konduku nin en tenton, sed liberigu nin
de la malbono. Car via estas la regado,
la forto kaj la gloro eterne.

Pater noster qui es in coelis,
sanctificetur nomen tuum;
adveniat regnum tuum;
ñat voluntas tua, sicut in coelo,
et in terra.
Panum nostrum quotidianum da nobis hodie;
et dimitte nobis debita nostra,
sicut et nos dimittimus debitoribus nostris;
et ne nos inducas in tentationem, sed libera nos
a malo.

NOTE.—Vowels have continental sounds. Consonants as in English. ĉ = ch in church, otherwise c = ts; s = sh; final j as y. Each syllable is pronounced. Accent on the penult.

It will suffice to conclude with a translated extract from a recent French memoir, entitled, "La Langue Universelle" (Hachette et Cie., Paris, 1904), by Couturat and Leau. This memoir is the result of a comparative study and research into all the published systems of international speech appearing within the past two hundred years. The authors are two members of an official delegation, appointed by the International Association of Academies, which undertook, at the instance of the French Academy of Sciences, to consider the adoption of an international auxiliary language. Concluding their critique of Esperanto, the writers say:

In spite of its imperfections, easy to correct, the system of formation of words in Esperanto is one possessed of remarkable regularity and fecundity. It is this, especially, which contributes to give it the striking character of a "natural" language, of a living tongue, which good judges recognize in it. It is truly an autonomous language, which possesses intrinsic and unlimited resources, which has an original physiognomy and a genius all its own. . . . It is therefore not an "artificial" language, dried and dead, a simple replica of our idioms; it is a language capable of living, of developing, and of surpassing in richness, suppleness and variety the natural tongues. Finally, it is a language susceptible of elegance and style, if one admits that true elegance subsists in simplicity and clearness, and that style is but the order which one takes in the expression of thought.

INFANT INDUSTRIES[1]

By Professor T. D. A. COCKERELL
UNIVERSITY OF COLORADO

THE university is, or ought to be, a nursery for young ideas as well as for young people. To an aged person like myself, there is something indescribably fascinating about a company of boys and girls. Who knows what they may do, what they may become? Do I not perhaps address myself to a Darwin, a Newton, or a Tennyson? Classes have grown up and gone away: not all their members have fulfilled our expectations; but yet, the harvest has been good—and who knows, who can tell, what is inherent in these *particular* green sprouts? It is the same with ideas as with people. Thoughts are born, mature, live their lives, struggle with one another, and finally reach their true position, if all is well. Alas! that is a large qualification, in either case. All may *not* be well; so much depends upon a favorable environment and that, of course, is what we are all trying to create.

There is one important difference between our young people and our young ideas. The former come to us at an age which—well, which seems to them quite grown up. The latter are often, we hope, born upon the premises, and raised by hand with tender care during their helpless infancy. Like other infants, they must not be forgotten, even for a little while, and they are subject to all sorts of infantile disorders. Unlike human infants, they have the unpleasant habit of destroying one another, and we, their nurses, are so heartless as to actually encourage this internecine conflict. Nevertheless, we prize them highly, and actively resent the sneers of passers by, who either have none of their own, or only horrid little brats we would not condescend to look at.

When very tender, they must often be kept at home. I used to be a student at a medical school in London, where we had a very original demonstrator of comparative anatomy. The results of our labors were tested in examinations held, not by the teachers, but by quite other and more aged professors. So our mentor used to say: "You see, gentlemen, this is so and so, but I only found this out the other day, and you must on no account tell it to the examiners, or they will give you zero." You will appreciate the immense advantage of being ex-

[1] Chapel address to the students of the University of Colorado, April 29, 1907.

amined by your own professor, all of whose heresies can be produced and accepted as current coin—perhaps even a little above par. Oliver Wendell Holmes justly remarked that you can not lift a stone without creating a panic among some of the centipedes and other crawling things which enjoyed the darkness it provided. Infant industries in the intellectual field are apt to be destructive of more things than toys, and so they are justly feared by the powers that be. There is this curiously complicated situation, that whereas intellectual progress is not merely advantageous to a nation, but is in this day of the world essential, it is of positive disadvantage to that numerous company to whom change means injury or destruction. This, however, is exactly what may be said of infants of flesh-and-blood: they are costly, troublesome, often noisy and ugly, and quite unable to do anything useful to compensate for all the injury and expense they involve. In the latter respect, they are much worse than their psychological parallels, for these are usually capable of rendering some service at a very early day. Why, then, do people ever raise children at all? Simply because they have learned to love them; this sentimental attitude has undoubtedly saved the race from extinction, and may be relied upon to do so for some time to come.

I see nothing for it, but the cultivation of a like feeling toward our beloved progeny of the mind. It should be one of the chief aims of university training, it seems to me, to cultivate an appreciation of progress, and an ardent feeling—yes, a sentimental affecting for these babes of the intellect. We should be not merely willing, but happy, to struggle hard to give them birth, to watch them daily, and if need be walk the floor with them at night. Many a man has shown just this devotion, has remained through the small hours with his eye glued to the microscope, or has refused to be comforted while the threads of his argument were still in a tangle. To most, I fear, all this must seem fanciful. I am not so quixotic as to hope that the beginnings of change will ever be widely understood. Nobody supposes that the parents of Shakespear knew the extraordinary value of the little wailing thing they had; nor it is possible for the originators of lines of thought to see where they will lead—much less the general public. Not only are we unable to rightly value our infants, but we have an uncomfortable feeling that some of them will do us no credit—or if we have not that feeling, some of our friends entertain it on our behalf. The truth is, we can not tell the good from the bad at a very early age, and the experience of mankind indicates that a charitable attitude is the wisest. Some of the best thoughts ever born into this world have appeared nonsense to the best friends of their parents.

I may be permitted to cite some instances in which ideas, cherished for the mere love of them, have done unexpected things in their mature

years. Somewhat more than forty years ago one Gregor Mendel, an Austrian priest, was raising garden peas. Instead of eating them, as you and I would have done, he observed and recorded the facts of inheritance they served to illustrate. Among other things, he discovered that in the case of pairs of opposing characters possessed by the parents of any given generation, some would be inherited in such a manner that half of the offspring, while apparently possessing only the character *A*, would in reality have also the other one, *B*, in their make-up—not visible at all, but ready to appear in another generation. That is to say, we may be indeed of the Jekyll-Hyde type, only the Jekyll alone appears in us, the Hyde in some of our children or *vice versa*. Without going into particulars, you can easily see that if, under such circumstances, the visible or dominant character is discriminated against by selection, the race possessing that character disappears; but as Dr. Shull has recently remarked, discrimination against the recessive or hidden character is ordinarily impossible, since in two thirds of the cases it is not visible at all, but is stored away in the germ cells to appear only in the next generation. The various important economic results flowing from the Mendelian researches—which were overlooked by naturalists for forty years, have been set forth in various places, but I may call attention to the possibility that certain forms of both virtue and vice, equally discriminated against by our modern civilization, are Mendelian recessives, and that is why they continue to appear in spite of everything. We stone the prophets, but it has not occurred to us to stone also the brothers and sisters of the prophets.

A few days ago, Dr. J. C. Arthur, of Purdue University, our foremost student of plant rusts, was here in Boulder. He told me something about his researches on the parasitic fungi of the different species of sunflower. It seems that certain sunflowers, which we will call *A*, have rusts which appear to grow exclusively upon them; while others, which we term *C*, are similarly afflicted. European mycologists had found that these parasites could not be transferred from *A* to *C*, or *vice versa*, and so had assumed that they were different species of fungi. But Dr. Arthur made the remarkable discovery that if the rust from *A* was sown on the common sunflower, which we will now term *B*, it would grow there, and would produce spores which would grow quite successfully on *C*. The process could also be reversed, causing the rust of *C* to grow on *A*, after a sojurn upon the intermediate *B*. It is greatly to the honor of the authorities of the Indiana Experiment Station, that they have—as I believe—supported Dr. Arthur in this work of his, and appreciated its value. In some places known to me, it would be quite otherwise, and I do not doubt that some of you are wondering whether, after all, this is a mere botanical curiosity.

However, putting aside the extraordinary scientific interest of such discoveries, and their bearing, ultimately, on the whole fabric of human thoughts; you will see readily enough that if a rust fungus can be transferred to a previously immune host through an intermediate form the planting of such a form in a certain region might be the cause of the ruin of a whole crop of wheat, oats, barley, or what not. Agriculturists have long sought, and thanks more especially to the knowledge derived from Mendel's researches, are learning how to isolate rust-proof types of cereals. In this way the pest may be overcome, but the vantage gained may again be lost in ways which would never be suspected, and could not be prevented, but for Dr. Arthur's illuminating researches.

Mr. W. L. Tower, of the University of Chicago, has been for many years conducting breeding experiments among beetles, choosing for that purpose the Colorado potato beetle and its immediate allies. Only the first part of his results has been published, but it is enough to show that he has found out some exceedingly interesting and important things and thrown new light on other matters not entirely new. For example, in breeding the beetles, he found that through a number of generations, the selection of extreme individuals (say dark, or light) for breeding did not sensibly modify the race. But by a process of very elaborate and careful breeding from isolated beetles, he discovered that sometimes a character was inherited fully, sometimes not to any appreciable degree, that is to say, it was possible to have two parents, *AA* and *AB*, looking exactly alike, but the first having, the second lacking, the property of producing offspring all closely similar to itself. The importance of such facts from an economic standpoint are hardly to be overestimated. Through such researches as those of Tower and Mendel, we are coming to understand why it is so difficult to improve a race by merely choosing those individuals which superficially appear to be of a desirable kind. It is necessary to isolate them, and test their properties through the character of their offspring, in order to separate pure races.

I have chosen only a few striking cases, and have said nothing about the infant ideas of our own vicinity. At some future time it may seem worth while to get up a local baby-show; the more so because, I regret to say, many of the infants known to me are lacking nurses, and I do not know of any hospitable door steps on which to leave them.

Ideas are not merely born once, but they suffer new births in the minds of many persons. In truth, they are not precisely repeated, but in each reincarnation are a little modified or augmented, so that the thought of every person about a given subject has its own individuality. This, however, presupposes that the child is alive, and not still-born. If it has any vitality, it will call attention to that fact by metaphorical

kicks and screams, quite as much as any ordinary infant. In all of this, the analogy with living people is again complete, for we ourselves are not entirely new, but merely repeat, with all-important modifications—the forms of our ancestors. The old text-book must not be discarded. It is full of information—and information is the food upon which ideas subsist. Many a good child of the intellect has been starved or warped because the fact-food supplied to it was deficient or bad. Adulterated fact is as bad as adulterated butter, sugar or lard; we can not have it chemically pure, I suppose, but woe to him who intentionally mixes wrong ingredients. The scientific men is devoted to truth; he is a pure-food man on the intellectual plane, and those who distort the truth for the purpose of warping the public ideas, are to him the worst of living creatures.

However, just as food, pure or impure, is of no use unless it is consumed, so information unapplied to the nourishment of thought is thrown away. I fear there is too much such waste among us, for the reason that we have not yet learned to think. The other day I passed two very little children, a boy and a girl, on their way to the University Hill School. The boy said to the girl, with the air of one communicating a most interesting fact, "Do you know, t, h, e, spells the"! Here was an example of the true spirit of science, the pleasure in the apperception of a new thing in its relation to something else. I must confess that the plane of this conversation was higher than that I usually overhear on the university campus.

THE FUTURE OF ECONOMIC ENTOMOLOGY

By Professor H. T. FERNALD, Ph.D.
AMHERST, MASS.

IT is now about three quarters of a century since the economic aspect of entomology was first presented for consideration in America, and this is perhaps an opportune time to survey the progress which thus far has been made, and in some degree to consider its future possibilities.

A careful examination of the writings of T. W. Harris, who may be termed the father of economic entomology in this country, shows several suggestive points. In his day the modern methods of using insecticides had not been discovered, and most of the treatments he suggested are included in the phrases hand-picking, whitewashing, cold water, fall plowing, cutting out borers and burning stubble for grain insects. Even in the cases where he advised the use of red pepper and tobacco, and soap or potash washes, the underlying thought seems to have been as much along the line of repelling as of destroying pests, and the idea of compelling insects to consume poisoned food appears to be entirely absent from his writings. Fumigation, too, though suggested in one instance, seems hardly to have had its possibilities appreciated, and it is probable that the most valuable contribution he made to the subject was the thought, quite new in this country, that insect depredations need not necessarily be accepted as in accordance with the will of God, but that active measures to prevent or reduce loss were possible.

Much has been learned since the days of Harris and new methods of control have replaced some of those he suggested. But it is discouraging to note that with many of our insect pests we stand to-day where we did then, and hand-picking, whitewashing, cutting out borers and fall plowing still occupy a prominent place in the entomological pharmocopœia.

Probably the most potent influence in the development of modern economic entomology was the spreading of the Colorado potato beetle to the east, and the resulting discovery that this pest could be controlled by the use of Paris green. That any insect consuming leaf tissues could be destroyed by applying a poison to be taken into its body along with its food was a discovery the credit for which will never perhaps be correctly assigned, but which marks the beginning of a new era in economic entomology, and rapid developments along this line followed,

resulting in the formulation of the general principle of the utility of stomach poisons. This has led to the investigation of many materials from the standpoint of their value as insecticides, together with determinations of their relative efficiency in different cases, how to control their effects and how they may best be applied, resulting in the development of spray pumps, nozzles and spraying apparatus in general.

Closely following the discovery of stomach poisons as insecticides came that of contact poisons for sucking insects, for though Harris had suggested soap solutions in one or two instances the general principle had until this time failed to be formulated. Here, too, investigation progressed rapidly, developing different materials as contact insecticides varying in strength and in their range of application until this field may now be considered to have been well explored.

Fumigation, as a method of control, during all this time remained almost unnoticed, its limitations being apparently so great, and the fumigants themselves being so mild as to give little promise of results of value. But during the last twenty years the utilization of gas-tight tents, and of hydrocyanic acid gas and carbon disulfid has shown that this method of control has a far wider range of applicability than was formerly supposed, and fumigation is now perhaps as well developed and its possibilities as thoroughly understood as is the case with stomach and contact poisons.

During the last three quarters of a century the ravages of insects have so greatly increased as to attract much attention to the subject, and many persons have become specialists in economic entomology. Numbering less than half a dozen in 1850, we now find more than five hundred workers, each year publishing thousands of pages on the results of their investigations. Large societies now hold regular meetings at which the problems of economic entomology are discussed; and the subject, once of little importance and of which almost nothing was known, has now become a large and important branch of applied science, with more positions waiting than there are competent persons to fill them.

The rapid increase in the losses caused by destructive insects, which has focussed so much attention on economic entomology is difficult to state accurately in figures, but was estimated in the report of the U. S. Commissioner of Patents (then in charge of the agricultural work of the government) in 1850, to be at least twenty millions of dollars, while other estimates of that period made in terms of the total crop value placed the loss at about ten per cent. Since that date conditions have changed materially and are continuing to change for the worse. The development of speedy commerce has enabled many of the most serious pests of foreign lands to reach and establish themselves here, till in addition to our own native insects we have also one hundred or more from abroad, many of them developing destructive

powers greater than in their native lands. The intensive agriculture and continuous acreage methods of recent years directly favor their rapid increase, and with the gradual reduction in numbers of our insectivorous birds one great check to their increase has been removed.

The result has been what might be expected. Estimates of the average annual loss by insects calculated at eighteen per cent., are now considered as about correct, and this loss on the basis of the United States government crop estimates for 1906 would be considerably over a billion dollars each year.

Nor is the end in sight. The pests of other lands are not yet all represented in the United States, though new ones arrive nearly every year. Agriculture is becoming more intensive, larger areas are being tilled, furnishing a more abundant and easily discovered food supply, and in spite of a healthy growth of interest in preserving our insectivorous birds, it is questionable if the developments connected with an increasing density of population will permit their preservation in any great numbers for more than another century.

This increase of loss has also occurred in spite of all the efforts of the economic entomologists, each one of whom can but acknowledge that while his efforts have not been in vain, the battle is nevertheless going against him, for in spite of all his efforts losses are becoming greater, insects more abundant and ultimate defeat seems certain, unless new and more effective methods can be brought into use in the struggle.

At the present time the economic entomologist is much in the same position as that of a physician who gives his prescriptions, but finds that many are never even taken to the druggist to be put up, while others, though prepared, are never taken and still others are taken but once. Many a crop is entirely lost by the neglect of its owner to apply the proper treatment and the value of many others is lessened one half or even three fourths by careless, shiftless work generally followed by entire failure to apply farther treatment because the first one being improperly or poorly made did not give the anticipated results.

If such are the existing conditions, what of the outlook? How long can this continue before greater crop destruction by insects and fungi, and an increasing population produce famine?

To these questions it is impossible to give decisive answers, though it is probable that many years are still between us and famine caused by insect ravages. But if an improvement of present conditions is desired, it would seem that it must come through the adoption of means by which spraying can be made more acceptable, or by the development of new methods of control.

The remarkable apathy of the crop producers of this country toward their insect foes, and their pronounced disinclination to carry out methods of treatment is an attitude which should be reversed as quickly and vigorously as possible. Much of this change must wait for a new

and more intelligent generation, better educated by our colleges and by training in agriculture in the elementary schools. Many a farmer today, however, would gladly spray or otherwise treat his crops if he knew how, but the details of the processes as usually printed serve only to confuse him, and the necessity for handling and mixing chemicals accurately he feels to be beyond his powers. To help this large class it would seem desirable for each state to organize a traveling force which should go from place to place and at each show how to prepare and apply the different materials most commonly used, together with the different kinds of apparatus for different purposes, thus enabling any one to see for himself how to make and apply the treatments needed.

It is very possible that this plan may fail to accomplish the desired results, for farmers as a class are notoriously slow to accept new ideas and new methods. Still it is one which has many elements of promise and should receive a thorough trial in all parts of the country before being rejected.

But where does the economic entomologist stand if this plan fails? For years he has urged, taught and demonstrated spraying methods as effective, and he knows that he is correct. But when his advice is for years persistently rejected by a large proportion of the people, as is still the case, it is certain that the time has now come to place economic entomology on a broader and more scientific foundation.

To accomplish this other lines of work are possible, none of which have as yet been given sufficient consideration. The entomologist who would be successful must soon study more fundamental problems rather than questions of petty detail, for if the fundamental principles are once correctly enunciated the details will then become merely individual examples and can be quickly and easily solved.

If man can not be relied upon to combat his insect foes, it is not improbable that nature may be induced to take up the warfare. In some cases it seems probable that careful plant breeding will result in the production of varieties resistant to the attacks of insects, and along this line experimental research promises much. The development of new plant forms which has been made so prominent recently by the experiments of Burbank and others is very suggestive, and the possibility of producing varieties not attacked by insects seems to have already been demonstrated in one or two cases to some extent.

In the case of insects having numerous food plants this method becomes less feasible, and here a scientific study of what may be termed entomological parasitology may prove useful. We must recognize that parasitic protection is never more than partial, but even a partial destruction of insect pests is of great value. The problem is beset with difficulties because of the existence of parasites on the parasites and by many other factors, and a single wrong conclusion such as the recent

statement that the *Ceratitis* on peach was effectually controlled by parasites in Brazil would be sufficient to discredit this entire method of investigation. For this reason only the best trained scientists especially educated for this line of work should attempt it and it would seem in many ways an appropriate work for the government to take up as it would necessitate much travel and expense, and its benefits would not be restricted to any one state.

If economic entomology is to attain success during the present century then it will be by inducing a more general adoption of the methods of treatment now known but not used generally enough; by the production of new, pest-resistant varieties of plants by experimental plant breeding; and by utilization of all the parasitic forces the world has available, establishing the parasites where their services are most needed and as free as possible from their own enemies. The old methods have proved too nearly useless because they have been so little adopted. A new departure must be taken and the world is waiting for a new Moses to lead the way out of the wilderness.

THE INSTINCT OF FEIGNING DEATH

By Professor S. J. HOLMES
UNIVERSITY OF WISCONSIN

THE so-called instinct of feigning death is one which is very widely distributed in the animal kingdom. It crops out sporadically, as it were, in forms which are but very distantly related, and hence it must have been independently evolved a great many times. The expression feigning death is a misleading one to the extent that it is apt to give rise to the idea that the animal consciously adopts this device with the intent to deceive. While it is probable, however, that among the higher animals which sometimes feign death there may be an attempt to mislead their enemies, it is quite certain that among the insects, spiders and other low forms there is no such aim in the creature's mind if we grant (what some naturalists are disposed to deny) that these animals have minds. The veteran French naturalist, Fabre, who has devoted the leisure periods of a long life to the enthusiastic study of the ways of insects, performed several experiments on beetles in order to ascertain if the duration of their feint was in any way affected by his own presence or movements. Most of Fabre's observations were made on a large scarab beetle. When handled the beetle would throw itself into an immobile state with its head bent down and its legs drawn in close to the body. It would remain in this attitude perfectly quiet for several minutes—sometimes for over an hour. Its awakening would be first manifested by a slight trembling of the feet and a slow oscillation of the antennæ and palps; then its legs would move about more vigorously, and finally the insect would arise and scamper off. Seized again, it would repeat the performance several times in succession, the duration of the feint often increasing with successive trials. Finally, as if wearied, or convinced that the ruse were vain, the beetle would refuse to feign longer.

Were the feints attempts to deceive its captor by simulating death? Fabre placed the insect on its back, went to a distant part of the room and remained perfectly quiet. The beetle still lay as usual. He then went out of the room, carefully looking in at intervals to watch the course of events. Still the same immobility. In other cases he covered the insect so that it could not see out and then quietly went away. This was also found to make no difference. In fact, whether the insects were surrounded by sounds and sights of moving objects or entirely excluded from these influences made no difference in the average length

of time they would remain in a motionless condition. Similar experiments have been made on other insects by different observers, who have all arrived at the conclusion that conscious deception plays no part in the process.

The attitudes assumed by insects and other forms when feigning death are usually quite different from those of dead specimens. This general fact was pointed out by Darwin, who says that "I carefully noted the simulated positions of seventeen different kinds of insects (including an *Iulus*, spider and Oniscus) belonging to distinct genera, both poor and first-rate shammers; afterward I procured naturally dead specimens of some of these insects, others I killed with camphor by an easy slow death; the result was that in no instance was the attitude exactly the same, and in several instances the attitudes of the feigners and of the really dead were as unlike as they possibly could be."

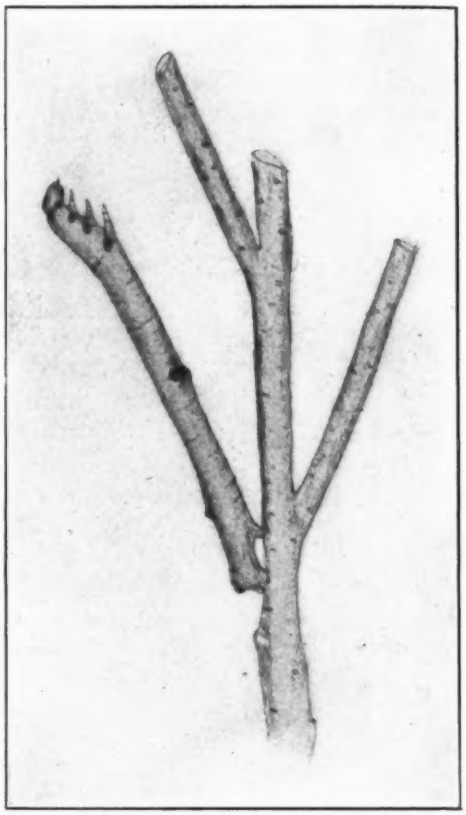


FIG. 1. LARVA OF A GEOMETRID MOTH ATTACHED TO A TWIG.

The attitudes of animals in the death feint are frequently very characteristic. Many beetles as well as other forms feign with the legs drawn up to the body and the antennæ closely appressed, so that the whole insect assumes as compact a form as possible. The woodlouse, *Armadillo*, rolls itself up into a ball with its legs drawn into the center, a habit which has doubtless caused the name pill-bug to be given to this crustacean. A beetle, *Geotrupes*, according to Kirby and Spence, "when touched or in fear sets out its legs as stiff as if they were made of iron wire—which is their posture when dead—and remaining motionless thus deceives the rooks which prey upon them. A different attitude is assumed by one of the tree-chafers probably with the same end in view. It sometimes elevates its posterior legs into the air, so as to form a straight vertical line, at right angles with the upper surface of its body."

Spiders usually feign by folding up their legs, dropping down and remaining motionless. The caterpillars of some of the geometrid moths have the curious habit of attaching themselves to a branch by their posterior legs and holding the body straight and stiff at an angle to the stem, thus forming a remarkably close resemblance to a short twig. Frequently the deceptiveness is increased by a marked similarity in color to that of the branch to which they are attached.

While in most cases a species has a particular attitude which it maintains when simulating death, there are some forms which feign in whatever posture they may be in when disturbed. A good example of this is afforded by the water-scorpion, *Ranatra*. This insect has the two hinder pairs of legs, which are employed in walking and swimming, very long and slender; the first pair are fitted for grasping the small aquatic animals on which it feeds and are carried straight out in front of the body. It is only necessary to pick one of these insects out of the water to throw it into a stiff, immobile condition which usually lasts several

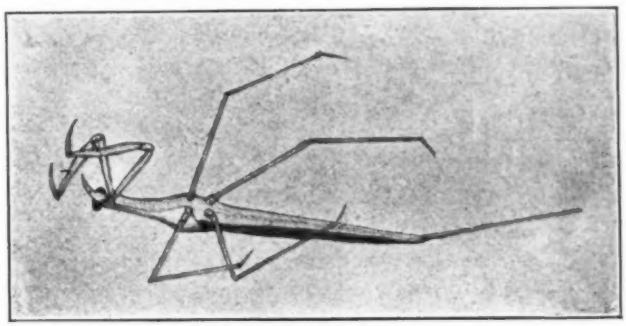


FIG. 2 A WATER SCORPION, *Ranatra*, FEIGNING DEATH

minutes and sometimes for over an hour. The legs may be closely pressed to the body so that the creature resembles a stick, or they may stand out at right angles to it, or be bent in any position, some in one way and some in another, depending upon how they happen to lie when the feint began. And no matter how awkward the position, it is rigidly maintained until the feint wears off. I have found that young *Ranatras*, the first day they emerged from the egg and while their appendages were still soft and easily bent, showed the same death-feigning instinct as the adults, although they did not persist in it for so long a time. It is a curious fact that the mature insects can not by any sort of manipulation be caused to feign death while underwater; but as soon as it is in the air it can be caused to feign repeatedly; sometimes a slight touch is all that is necessary to throw it into a rigid state of an hour's duration.

Death feigning does not seem to occur among the lower invertebrate animals such as the Protozoa, Cœlenterates, Molluscs and worms, although some of them may exhibit reactions which are prophetic of this

instinct. Among Crustaceans the instinct in its fully developed form is quite uncommon. Some years ago I described the death-feigning of certain species of terrestrial amphipod crustaceans which are frequently found on sandy beaches near the seashore. On account of their peculiar hopping movements these crustaceans are commonly known as sand-hoppers or sand-fleas, although they have of course no relation to the ordinay fleas of human experience. One of the largest species of sand-hopper, *Talorchestia,* is common along our Atlantic coast, where it lives during the day in burrows made in the sand, coming out only at night to feed upon the seaweed and other material washed ashore by the waves. When the Talorchestias are dug out of their burrows,

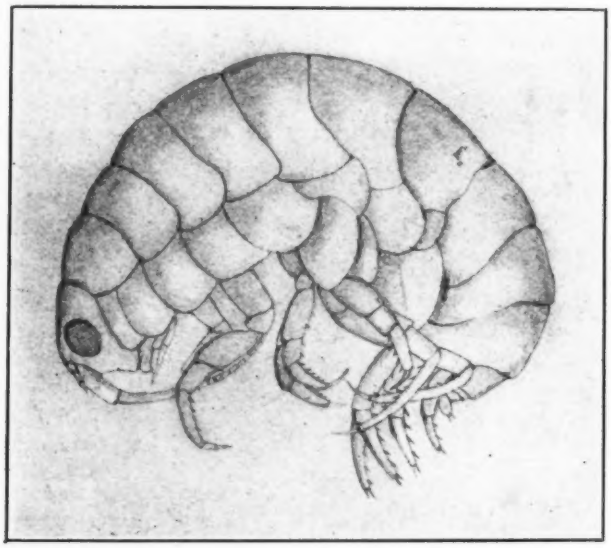


FIG. 3. A SAND-FLEA, *Talorchestia*, IN THE DEATH FEINT.

they usually lie curled up with their long antennæ bent under the body and their legs drawn up so as to assume a compact form. They will lie in this way for several minutes, when they may be seen slowly to relax; the legs then move about, and soon the creature hops away by a sudden extension of its abdomen. When caught in the hand they will feign death again, and repeat the performance many times in succession. Other species of sand-hoppers exhibit the same instinct, though less perfectly, and there are traces of it in many of the reactions of their aquatic relatives.

The various species of wood lice exhibit the instinct of feigning death in various degrees. Some species are able to roll up into an almost perfect ball and will remain in that state for a considerable time. Other species curl up, but make only a very imperfect approximation to a sphere, and they may not maintain this attitude but for a short period. Some myriapods when disturbed curl up in much the

same way. Among spiders death-feigning is not uncommon, especially among the orb weavers.

It is among the insects that the death-feigning instinct reaches its fullest development, occurring to a greater or less extent in most of the orders. It is especially common in beetles and not unusual among the bugs, but it is quite rare in the highest orders such as the Diptera or flies, and the Hymenoptera, or the ants, bees and their allies. It occurs in a few cases among butterflies and moths, both in the imago as well as the larval state. The instinct is exhibited in different species in all stages of development from a momentary feint to a condition of intense rigor lasting for over an hour. Some insects may be severely mutilated, or, according to De Geer, even roasted over a fire before they will cease feigning.

Among the vertebrate animals death-feigning has been observed only rarely in the fishes. In the Amphibia it is not exhibited in the striking way it occurs in insects and spiders, although frogs and toads may be thrown by the proper manipulation into an immobile condition more or less resembling it. A phenomenon apparently related to the death feigning of insects has long been known in certain reptiles. Darwin in his "Journal of Researches" describes a South American lizard which when frightened "attempts to avoid discovery by feigning death with outstretched legs, depressed body, and closed eyes; if further molested it buries itself with great quickness in the loose sand." The Egyptian snake charmers by a slight pressure in the neck region are able to make the asp suddenly motionless so that it remains entirely passive in the hands of the operator. And similar phenomena have been found in other species.

In birds the instinct crops out only here and there. A few summers ago when on the island of Penikese I was somewhat surprised to find the instinct well developed in the young terns which were hatched out in abundance on the hillsides. For a short time after being hatched the little downy fellows betray no fear of man and will cuddle under one's hand in perfect confidence. When the birds become larger and acquire their second coat of feathers the instinct of fear takes possession of them and they run and hide in the grass when you approach. Here they lie perfectly quiet; you may pull them about, stretch out their legs, necks, or wings and place them in the most awkward positions, and they will remain as limp and motionless as if really dead. They will even suffer their wing or tail feathers to be plucked out one by one without a wince. But all of a sudden the bird becomes a very different creature. It screams, pecks and struggles to escape. I have made several attempts to make a bird feign death a second time, but never met with success. According to Couch the land rail and skylark feign death, and Wrangle states that the wild geese of Siberia have the same habit during their molting season, when they are unable

to fly. Hudson states in his most interesting "Naturalist on the La Plata" that the common partridge of the pampas, when captured, "after a few violent struggles to escape drops its head, gasps two or three times, and to all appearances dies. If, when you have seen this, you release your hold, the eyes open instantly, and with startling suddenness and noise of wings, it is up and away and beyond your reach forever."

In mammals the instinct is so well shown in one of the lower members of the group, the opossum, that the expression "playing possum" is familiar to every one. Foxes when trapped or hard pressed often drop down limp and apparently lifeless and will even endure a good deal of maltreatment without making any response. Hudson records that he was "once riding with a gaucho when we saw, on the open level ground before us, a fox not yet fully grown standing still and watching our approach. All at once it dropped, and when we came up to the spot it was lying stretched out, with eyes closed, and apparently dead. Before passing on my companion, who said it was not the first time he had seen such a thing, lashed it vigorously with his whip for some moments, but without producing the slightest effect."

Mr. Morgan in his book on the beaver gives the following instance on what he assures us is excellent authority: "A fox one night entered the hen-house of a farmer, and after destroying a large number of fowls, gorged himself to such repletion that he could not pass out through the small aperture by which he had entered. The proprietor found him in the morning sprawled out upon the floor apparently dead from surfeit; and taking him up by the legs carried him out unsuspectingly, and for some distance to the side of his house, where he dropped him upon the grass. No sooner did Reynard find himself free than he sprang to his feet and made his escape." Dogs are frequently deceived by this ruse of the fox and doubtless foxes have many times owed their lives to its aid. It has been often noticed that if one withdraws from a fox when it is feigning it may be seen to slowly open its eyes, then raise its head and carefully look around to see if its foes are at a safe distance, and finally scamper off.

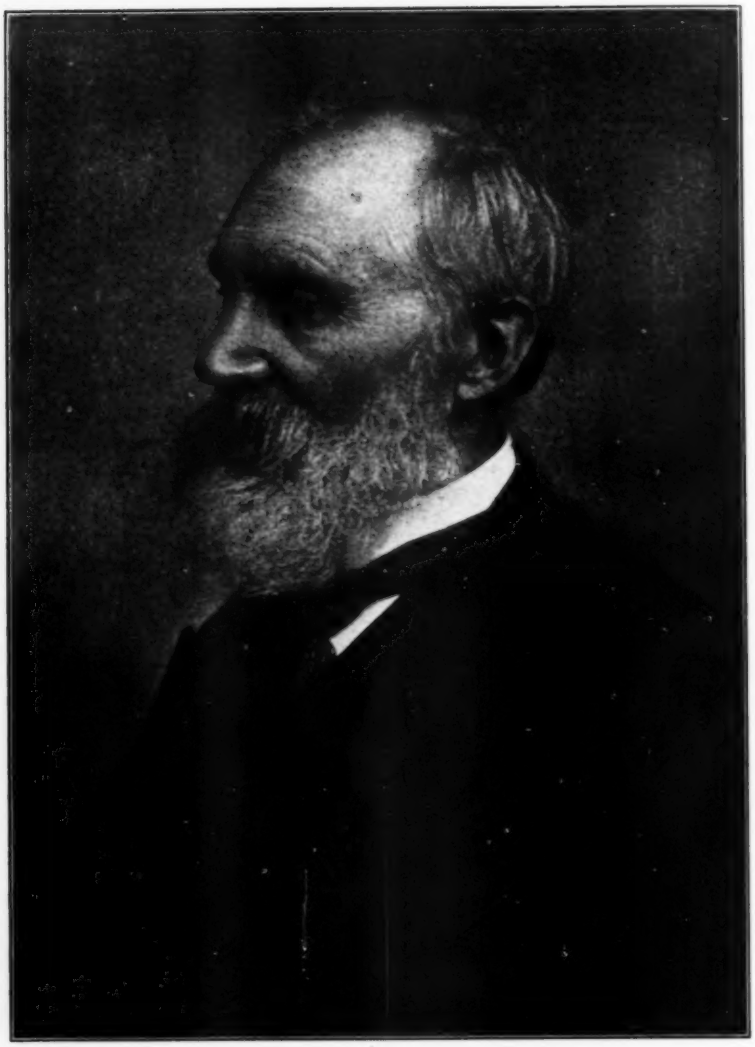
While in insects the instinct of feigning death is probably a simple reflex reaction to outer stimuli, it is doubtless associated in birds and especially mammals with a tolerably acute consciousness of the situation. It involves a more or less deliberate intention to profit by the deception, yet at the same time it is probably not a result of conscious reflection. The instinct is there, or else such a course of action would not occur to the animal's mind. Were it otherwise it would be difficult to understand why the ruse is adopted only by certain species while many others, equally intelligent and for whom it would be an equally advantageous stratagem never manifest it. There can be little doubt that a fox which slowly opens its eye and warily looks around is

acting with an intelligent appreciation of his predicament, but it is not to be inferred that he could have reasoned out his course of action did not an innate proclivity in that direction form a part of his instinctive make-up.

The physiological condition in what is called death-feigning is quite different in different forms. In most of the lower animals it is characterized by a tetanic contraction of the muscles. The attitudes assumed by many forms, such as rolling into a ball, keeping the legs and other appendages drawn close to the body, or in some cases holding them straight and rigid, are such as can be maintained only at the cost of considerable muscular effort. If a *Ranatra* is picked up by one of its slender legs it may be held out horizontally for a considerable time without causing the leg to bend. It is as if a man were seized below the knee and held out straight, face upward, without causing the knee to bend; only the legs of a *Ranatra* are several times more slender than those of the most attenuated of the human species, and the muscular tension which the insect maintains must therefore be intense.

The death feint of insects and other low forms is not entirely dependent on the brain. It is due rather to a general physiological state of the animal. I have found that the posterior part of the body of a *Ranatra* can still be induced to feign death, though less perfectly, when entirely removed from the head and prothorax. When it would come out of the feint a few light strokes would cause it to feign again. It has been found that spiders also may still feign after entire destruction of the brain.

The instinct of feigning death is doubtless closely connected with much of what has been called hypnotism in the lower animals. Crayfishes, frogs, lizards, certain snakes and many birds and mammals, may by a very simple process be thrown into an inactive condition from which they are not readily aroused by external stimuli. In ordinary death feigning the animal falls into its immobile state upon slight provocation; a touch, or even a jar is sometimes all that is necessary. In the so-called cases of hypnosis more or less manipulation is necessary. The exciting cause in both cases is generally some form of contact stimulus. In the hypnotism of animals, as Verworn and others have shown, there is diminished reflex irritability, and usually tonic contraction of many at least of the muscles. Similar phenomena are observed in the death feigning of many forms, some of the insects showing a lack of responsiveness that is truly remarkable. In a water-scorpion that is feigning death the legs may be cut off one by one, or the body cut in two without eliciting the least reaction from the unfortunate victim. We can only speculate at present on the condition of the nervous system which makes such a result possible.



LORD KELVIN.

THE PROGRESS OF SCIENCE

LORD KELVIN

THE tomb of William Thomson, Baron Kelvin of Largs, now stands beside that of Darwin in Westminster Abbey, and a great epoch in history is closed. The nineteenth century will remain preeminent for the supremacy of science and for the advance of industrial democracy. Great Britain more than any other nation has led these movements, and no other of its great men so completely typifies them as he who ranged from cosmic speculations to industrial inventions, who brought together mathematical physics and practical engineering.

While Kelvin retained to the age of eighty-three years much of the vigor, keenness and intellectual curiosity of youth, he belongs in a sense to the middle of the nineteenth century rather than to the more complicated period of its close. For the grandson of an Irish peasant farmer to amass great wealth, discard his plebian name and take a seat in the house of lords is a social ideal of the earlier rather than of the later democracy. So Kelvin's science was static of the forties. He liked models that he could visualize; he did not care for the doctrine of evolution; even in his own field the researches of others did not greatly affect him. This is perhaps typical of genius, especially mathematical genius, which seems to develop early, to be likely to be hereditary and to be comparatively unaffected by external conditions.

Kelvin's father, without early opportunities, became professor of mathematics in Glasgow University, and his brother was professor of engineering there. Kelvin was appointed to the chair of natural philosophy at the age

LORD KELVIN,
then William Thomson, at the age of twenty-two, when just elected to the Chair of Natural Philosophy at Glasgow.

of twenty-two. He matriculated as a student at the age of eleven, and at the age of seventeen began to publish papers on the mathematical theory of heat. Migrating to Peterhouse, Cambridge, he became second wrangler. Within four years Stokes, Cayley and Adams had been senior wranglers, illustrating the precocity of mathematical genius and the mathematical activity of Cambridge at that period. For fifty-three years Kelvin was professor of natural philosophy at Glasgow. Like Helmholtz he was not a good lecturer, but like his great German friend he exercised an enormous influence on the progress of science directly as well as by his published work. The jubilee of his professorship was adequately celebrated in 1896; from the volume giving some account of it, the portraits here reproduced are taken. Kelvin was president of the Royal Society and of the British Association, and was active in their work, rarely failing to take a leading part at the annual meeting of the association. All the highest scientific honors were of course conferred on him. He was twice married, but leaves no issue.

To the general public Kelvin is best known for his share in submarine telegraphy, for his improvements in the compass, for his machine for taking soundings and for other inventions, scores of which he patented. To the electrician and the engineer many important instruments and improvements in methods of measurement will occur, such as his three electronometers, his mirror galvanometer and his syphon recorder. With Professor Tait he began a "Treatise on Natural Philosophy," which has become a classic for parts of mechanics. His popular addresses have been published in three volumes. But it is only the scientific man who can appreciate the range and originality of Kelvin's performance. As Shelly is the poet's poet and Velasquez the artist's artist, so Kelvin is the man of science who appeals especially to his fellow-workers. They may criticize what they regard as his limitations, but they are full of admiration for the man and his work. It covers an immense field—elasticity, hydrodynamics, heat, electricity and magnetism, the nature of the ether and the constitution of matter. This is not the place to attempt to describe his experimental work or his far-reaching speculations. A sketch will be found in the tenth volume of this magazine, and among the many obituary notices we may refer especially to one in the issue of *Science* for January 3, by Professor Webster.

It is pleasant to remember that Kelvin three times visited this country. He brought Great Britain and the United States closer together by his contributions to transatlantic telegraphy and to navigation, and his most elaborate mathematical speculations are to be found in the lectures given at the Johns Hopkins University in 1884 and published many years later under the title "Molecular Dynamics and the Wave Theory of Light."

THE CONVOCATION WEEK MEETING AT CHICAGO

THERE was a notable assemblage of scientific societies and scientific men at the University of Chicago during convocation week. Not hitherto has there been such a meeting west of the Atlantic seaboard. This is gratifying as an indication of the increased readiness of scientific men to cooperate in their organizations, and especially as a demonstration of the great growth of science in the central states. The American Association for the Advancement of Science last met at Chicago forty years ago. It was the seventeenth meeting and the third in size, the attendance being 259, of whom probably less than half were scientific men. Other meetings held so far to the west with the registration have been: 1877, Nashville, 173; 1878, St. Louis, 134; 1883, Minneapolis, 328; 1893, Madison, 290; 1901, Denver, 311; 1903–4, St. Louis, 385; 1905–6, New Orleans, 233.

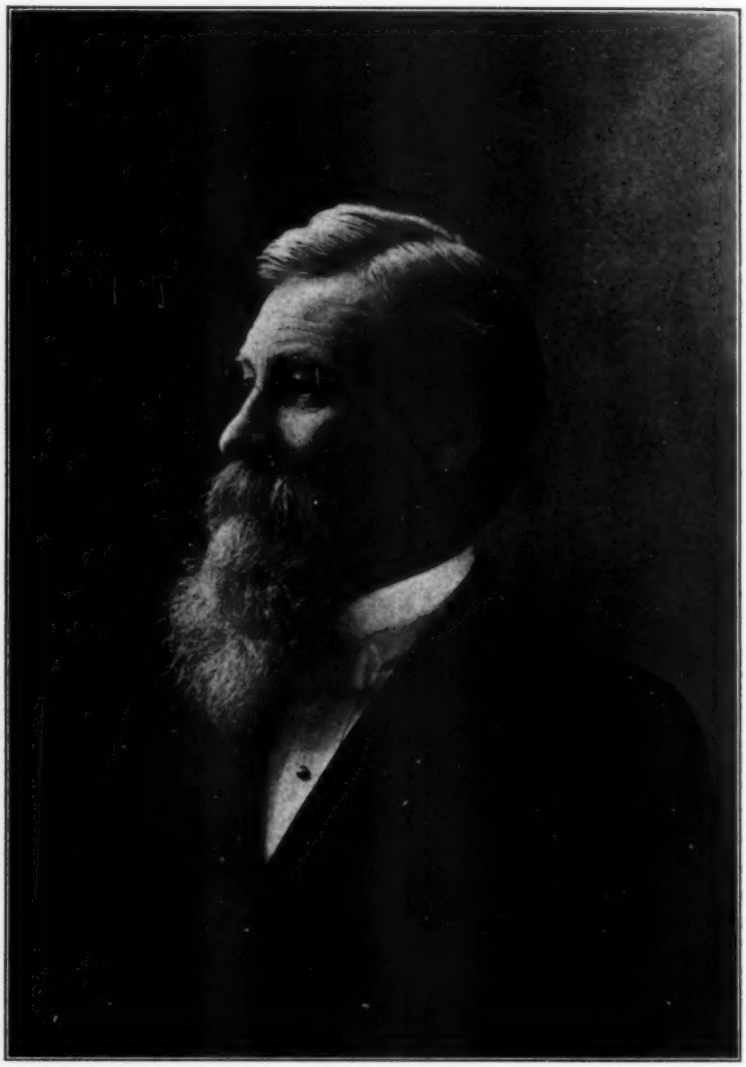
E. O. LOVETT, Ph.D.,
Professor of Astronomy at Princeton University. Retiring Vice-president and Chairman of the Section of Astronomy and Mathematics. President-elect of the Rice Institute.

It will be noted that in recent years the association has fulfilled its mission as a national organization by meeting as far west as Denver and as far south as New Orleans. But the registration has been comparatively small. At the present Chicago meeting the registration was 725, and the general secretary estimates that this represents an attendance of scientific men close to two thousand. This is only about twenty per cent. less than at the largest eastern meetings.

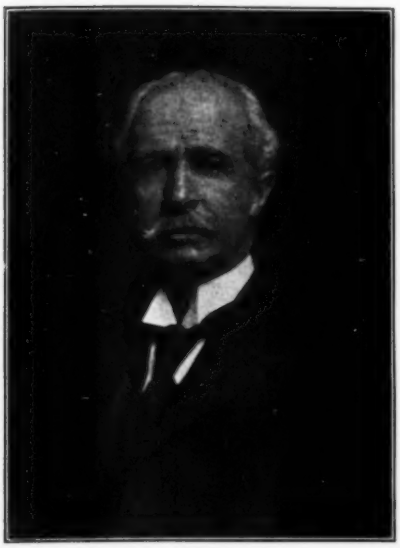
The magnitude of the meeting is mainly significant as the most convenient measure of its scientific importance. There were 159 papers on the programs of the American Chemical Society, the American Society of Botanical Chemists and the Chemical Section of the Association. While the chemists are the largest group, the programs of special papers in other sciences were in proportion. There were also many general addresses and less technical sessions. First should be mentioned the address of the retiring president of the association, Dr. W. H. Welch, of the Johns Hopkins University, who traced with characteristic charm and clearness the historical interdependence of medicine and other sciences of nature. The standard set by this address was maintained by the chairmen of the sections and the presidents of the affiliated societies. Among the general discussions should be mentioned that before the American Society of Naturalists on cooperation in biological research, and those before sections of the association on public health, immunity and the teaching of mathematics to students of engineering. The well organized and interesting sessions of the newly organized section of education, with the address of its first chairman, Dr. Elmer E. Brown, United States Commissioner of Education, deserve special mention.

The American Association is becoming increasingly a center for affiliation and organization, the special programs

DAYTON C. MILLER,
Professor of Physics, Case School of Applied Science. Retiring Vice-president and Chairman of the Section of Physics.



T. C. CHAMBERLAIN, LL D.,
Head Professor of Geology at the University of Chicago and President of the American Association for the Advancement of Science.



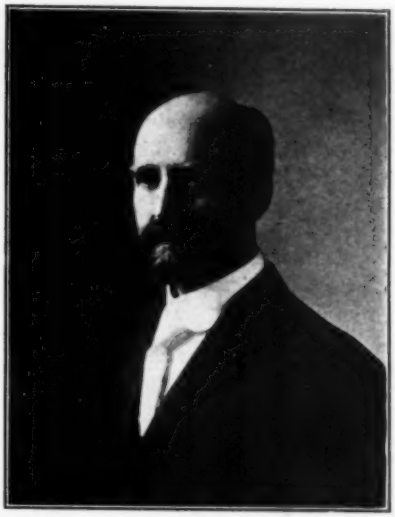
J. P. IDDINGS, Ph.D.,

Professor of Petrology, at the University of Chicago. Retiring Vice-president and Chairman of the Section of Geology and Geography.

CHARLES E. BESSEY, Ph.D.,

Professor of Botany, University of Nebraska. Retiring Vice-president and Chairman of the Section of Botany.

being in large measure delegated to the national scientific societies, while the council, representing both the parent association and the affiliated societies is able to speak with authority in behalf of the science of the whole country. The number and character of the resolutions passed by the council at the Chicago meeting is significant. In response to a letter from the president of the United States a committee was appointed on conservation of the natural resources of the country. Resolutions were passed recommending a research laboratory for tropical dis-



ELMER ELLSWORTH BROWN,

U. S. Commissioner of Education. Retiring Vice-president and Chairman of the Section of Education.

eases at the Isthmus of Panama and a biological survey prior to the migrating of marine animals that will occur when the canal is completed, supporting the committee of one hundred in its efforts to increase the efficiency of the government in dealing with problems of public health, advocating the enlargement of the work of the Bureau of Education, favoring work in seismology by the national government, and in other directions. The association will a year hence com-

memorate the hundredth anniversary of the birth of Darwin and the fiftieth anniversary of the publication of the "Origin of Species."

The University of Chicago offered admirable facilities for the meetings and provided in every way for the entertainment of members, while the other institutions of the city showed all possible courtesies. The social events closed fittingly with a dinner to commemorate the conferring of the Nobel Prize and the Copley Medal on Professor A. A. Michelson. The University of Chicago was also able to supply a distinguished president for the next meeting. Professor T. C. Chamberlin, one of the world's greatest geologists, will maintain the high traditions of the office, so well represented at the Chicago meeting by Professor E. L. Nichols, of Cornell University. There will be a summer meeting of the association at Hanover, N. H., on the invitation of Dartmouth College, beginning on June 28, and the next convocation week meeting will be held at Baltimore during New Year's week on the invitation of the Johns Hopkins University.

SCIENTIFIC ITEMS

WE regret to record the death of Charles Augustus Young, the eminent astronomer. A sketch with a portrait will be found in THE POPULAR SCIENCE MONTHLY for July, 1905.—We further much regret to record the deaths of two other distinguished American men of science: Dr. Nicholas Senn, the surgeon, and Dr. Coleman Sellers, the engineer.—Among foreign men of science the deaths have occurred of M. Janssen, director of the Meuden Astrophysical Observatory, and of Dr. Alphonso Sella, professor of experimental physics at Rome.

THE Hayden memorial medal of the Academy of Natural Sciences of Philadelphia has been conferred on Dr. Charles D. Walcott, secretary of the Smithsonian Institution.—Professor Simon Newcomb has been elected a foreign member of the Göttingen Academy of Sciences and Mr. G. K. Gilbert a corresponding member of the Munich Academy of Sciences.—Dr. W. W. Keen, professor of surgery at Jefferson College, has been elected president of the American Philosophical Society, Philadelphia, to succeed Professor Edgar F. Smith, vice-provost of the University of Pennsylvania and professor of chemistry, who declined reelection.—The American Philosophical Society will hold a general meeting on April 23, 24 and 25.

MR. JOHN D. ROCKEFELLER has added $2,191,000 to his previous gifts to the University of Chicago, making the total amount of these nearly $24,000,000. Of Mr. Rockefeller's recent gift, the sum of two million dollars is for permanent endowment; the sum of $155,000 is to meet the deficit for 1907, and the sum of $36,000 is for miscellaneous purposes.

BY the will of the late William George Pearce, Trinity College, Cambridge University, receives about two million dollars. This is one of the largest gifts or bequests ever received by an English university.